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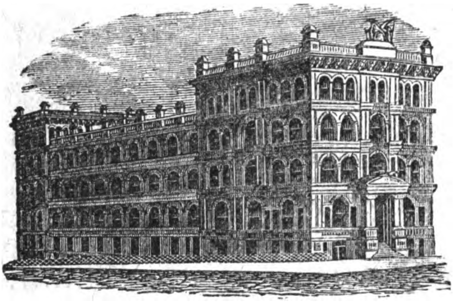

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THE

POPULAR SCIENCE
MONTHLY.

NOVEMBER, 1875.

THE RELATIONS OF WOMEN TO CRIME.

By ELY VAN DE WARKER, M. D.

I.

THE first traditional crime, the fratricide of Abel, was a natural outgrowth from the conditions of society, which, compared to the present relations of civilized men, existed germ-like around him. These conditions alone gave motive and direction to the deed. To all the after-centuries of human crime this primal offense has existed as a type. Both in cause and effect it is reduced to its simplest proportions. The criminal represents the retrograde tendency of society; the savagism which exists in every community. Order and progress are preserved by an irrepressible conflict waged on the border-land, as it were, of civilization. Many of these crimes grow out of the artificial wants of society. Others are but relative and belong to particular conditions, or orders of men, and at other times and places are without meaning and void of offense. Thus society is ever eager for the warfare, and, at the time it creates the crime, prepares the weapons for its punishment.

The propensity to crime is a fixed element in human nature. Quetelet, whom I have frequently referred to in the course of these papers, has with singular sagacity and perseverance reduced the social relations of man nearly to an exact science. The dark and tortuous by-ways in life, which so many seem perforce to follow, arrange themselves with the regularity of geometrical lines under the clear illumination of his analysis. Yet these are surface-lines only. There are profound depths of human misery and crime, over which a veil seems drawn by a merciful hand, and in which we have but a suspicion of the force of law. But, in these depths, in which the terminal fibres of human relations find soil and sustenance, can be found the origin of the ordinances under which these surface-lines are grouped. If this be so, it follows that crime must be studied as a natural phenom-

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enon rather than as an accident. Those efforts which society has made to stamp out and confine this tendency to evil must, to an equal extent, spring from higher law; just as a breakwater is reared to protect an exposed harbor from the encroachments of storm and wave.

We have of late years come to look upon criminals as a special class of the community. We have come to complacently call them the "criminal class," just as we do the mercantile class or any other reputable order of men. This is so far true as to be capable of proof more by the exceptions than the rule. We have come to look upon crime as we do the typhus fever or the cholera, as prevailing mainly amid dirt and ignorance. I believe this to be true only so far as ignorance permits those good qualities in men to be undeveloped which require culture for their development; and the existence of such qualities has not as yet been demonstrated. It must be understood that while the word "ignorance" does not express a positive quantity, it yet expresses a positive quality which is true of the mass of people. This word with perfect fairness may be applied to the vast numbers which swell the aggregate of a census-table, without any qualification. I believe it can be shown that it is simply from excess in numbers that the ignorant classes furnish the recruits to the ranks of crime, and not from any tendency to crime dependent upon the negative quality of ignorance. A careful analysis of facts in this field induces Mr. Buckle to say that "the existence of crime, according to a fixed and uniform scheme, is a fact more clearly attested than any other in the moral history of man."[1] Another high authority may be quoted in evidence to prove that this scheme is exempt from those laws which govern intellectual development: "It is one of the plainest facts that neither the individuals nor the ages that have been most distinguished for intellectual achievements have been most distinguished for moral excellence, and that a high intellectual and material civilization has often coexisted with much depravity."[2]

All this seems to show us that there is a rhythm in human actions that forms a minor chord in the forever unwritten music which those who love Nature know as existing profoundly in all her works.

Since we are dealing with an element in human character which preserves a fixed value, it is evident that we may study the relation of any class in any community to these constantly-recurring phenomena, provided we can isolate this class from all others. In the study before us, this has already been done by the division of mankind into the sexes. I need draw no other line. Women stand out so clearly as a class, and, in relation to any series of acts which preserve a more or less constant periodicity, are so sharply defined from man, that they are easily contrasted with him in relation to any condition common to both.

[1] "History of Civilization in England," vol. i., pp. 22, 23.

[2] "History of European Morals from Augustus to Charlemagne," vol. i., p. 157.

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I have already called attention to the fact that intellectual development obeys other laws than those which relate to crime. This requires to be brought out more clearly in relation to women. In this age women are receiving more chivalric attention, more material respect, than in any other known to history. In this century they are accorded the full right, and are given the aid of some of the best intellects among the other sex, to adjust those wrongs under which they have labored for ages. They are identified with every scheme of love and purity which demands good motives and a sympathy that never slumbers. It is for this reason, then, that, when we associate women with the idea of crime, it is difficult to believe that they are not influenced by other laws than those which affect men. There is nothing in a brawny hand and coarse muscle which tends to evil. The hand which executes may be white and begemmed. The mind which plans may be cultivated and refined.

In the study before us, we shall be obliged to resort to other facts than those simply contained in tabulated statements of crime. Statistics has done much in social study, and in this instance it has pointed out the existence of law in human action in the aggregate; but it has gone no deeper. We can establish by its means a probable difference in the degree to which the sexes are affected by crime; we can so group these numerical statements that they will be a mutual check upon each other, but if we are to learn any thing of the under stratum of human life, of its curves and faults, of which we see only here and there an upheaval upon the surface of society, we must study sexual and general character, we must observe the mutual relation and dependence of the sexes and classes upon each other, and give due credit to the cerebral and physical differences which go to make up the sum of sex—all of which are beyond the province of figures to express. In the course of these papers, therefore, I shall resort to statistics only to the extent I have mentioned. The popular character which I have endeavored to give them also forbids the resort to statistical detail, except to the extent which is inseparable from the nature of the study.

As in hygiene so in crime, there is not one law for woman and another for man. The emotions which impel to crime are few, and to the operation of which the sexes are both exposed. But, it does not follow that these causes react in the production of crime to an equal degree. The propensity to crime, as defined by its actual commission, is four times as great in men as in women.[1] Here at the outset we are confronted by a remarkable contrast. But, allowed to stand as here stated, it involves a vital error. A propensity to crime is its existence latent in the possibilities of the individual. Justin McCarthy, in one of his novels, in describing a character defines her virtue as purely anatomical while mentally most unchaste. Here the propensity was one thing and its physical expression another. It therefore follows that if we are to reach the degree of woman's propensity to crime it must be by other means than a simple expression of the difference in the actual perpetration of total crime. The propensity can be approximately measured by the degree of the offense. Quality and degree are in law the measures of the punishment inflicted on the offender. This is called justice, and it is indeed tempered with mercy when we compare it with the operations of law less than a century ago, when it dealt with crime simply as a quality without reference to degree. In its treatment of criminals, society took its first scientific stand-point when it measured the propensity to evil by the degree of evil actually committed. It seems safe to assume that in a certain limited range, as the degree of crime defines its penalty, so also it expresses the extent of the propensity. Another fact may be approximately established from the same data. The causes of crime, those deeply-hidden undercurrents existing in society, the ebb and flow of which seem to register themselves in undeviating curves of human conduct, must vary in intensity to the degree of crime which is their natural outgrowth. Thus, a man who commits a criminal act with the full knowledge that his life is jeopardized thereby must surely be exposed to an influence far greater than one who, under all circumstances, would shrink from the greater crime through a sense of punishment, but would not hesitate to commit a lesser offense. If this is not so, then society has been acting upon a false theory in its repression of crime by the fear of punishment. But I believe legislation for this purpose has been based upon a correct knowledge of human nature, and that the average man with criminal tendencies is, to a certain degree, deterred from criminal conduct by a fear of punishment. There is strong confirmation of this in the condition of society existing in the border States and mining regions, in which there is a low estimate of the value of human life, not from the fact that life is individually less precious there than elsewhere, but that the tendency to this form of crime exists in greater force as a natural outcome of the conditions under which human life is there grouped. I believe it is just, therefore, to partly form an estimate of the tendency to crime by the method I have adopted, aided by a simple comparison of the prevalence of crime in general in the sexes.

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[1] Quetelet, "A Treatise on Man," p. 70.

The apparent great excess in the prevalence of crime among men forms one of the most interesting facts of sex in crime. At the outset we ought to reach, if possible, the cause. In this connection all ideas of the innate morality of women over men must be abandoned. Modern literature is full of a false and even morbid idea upon this subject. M. Michelet has written a romance called "Woman,"[1] and it is a fair sample of what may be termed the sentimental estimate of the sex. But the frail creature portrayed in the florid sentences of Michelet is not the woman of France. One glance at the tables of Quetelet proves this.

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[1] "Woman," from the French of M. Michelet, by J. W. Palmer. New York, 1874.

We must take a practical view of woman's character. She must be regarded as one in whom the passions burn with as intense heat as in the other sex. The limits of her morality are the same as man's. She attains purity in the same manner; and she meets sexual disaster through the same means. Her worldly view is bounded by the same horizon. She upholds for herself the same standard of success or failure. Temptations run in the same channel and are resisted by the same psychical traits. The forces of heredity play the some *rôle* in her mental and bodily life. Beyond these, she belongs to a different mental type from man, the effects of which in our present knowledge, and in the relations we are now studying the sex, reach limits impossible to fix. I can see no other way of viewing the sex, and reaching any thing like approximate truth in her relations to crime.

In crimes against persons in which personal strength forms an element, there is a physical factor for the difference. The ratio of strength between the sexes is as sixteen to twenty-six, and this is found to correspond to the difference in which women and men participate in crimes against persons and property.[1] Such a coincidence as this, constantly recurring, renders, in this broad classification of crimes in general, such an explanation probable. But, in a closer analysis of crime in particular, this physical basis loses its value as a probable cause. While we must allow that sexual difference in strength finds a reflex result in consciousness, and thus places a limit to the acts of either sex, yet in crimes against persons we find the sexes approaching to and receding from a common ratio. It is this fact which leads me to the conclusion that all argument regarding the innate excess of moral qualities in the female sex over the male, is based upon a fallacy. It is strongly confirmatory of this, that a simple numerical comparison of the prevalence of crime in the sexes leads to error, unless we credit women with the fewer temptations, the less opportunity, and those forms of sexual cerebration which find their expression in a want of belligerence which characterize women. Thus it would be obviously wrong to assert that, because twelve women to one hundred men are convicted of assassination, women represent more than eight times the morality of men in relation to this one offense. This crime is just the one to call into play all those conditions which constitute the moral atmosphere and conditions of sex. Woman's want of opportunity, the nature of her occupations, and the absence of the same degree of temptation, must all be taken into consideration in forming an opinion of the moral equivalent of women in connection with the crime. If it were possible to give to each one of these modifying conditions a numerical expression, this moral equivalent could be given a mathematical value. But this is impossible, and each possesses in itself an imaginary yet appreciable value. Again, let us group all those crimes against persons which involve the taking of human life, and observe the extent to which the sexes are engaged. For all crimes against persons, Quetelet places the ratio at sixteen to one hundred; but in the class of crimes I have selected, involving infanticide, poisoning, parricide, assassination, and murder, we find this ratio nearly doubled, being thirty to one hundred. It is evident that woman's tendency to crime must be measured by some other standard than innate morality. If we apply to these figures the theory that the degree of crime is in a measure the test of propensity, we obtain some startling results. Take the felonies named above in the aggregate, and while the marked difference of sex in the commission of total crime is evident, we see that in the perpetration of these grave offenses she exceeds her ratio of crimes against property. I think this shows the probability that those emotions or passions which serve as the incentives to crime, approach in intensity the same mental conditions in the other sex. When we consider the strong emotional nature of women, and that many of these emotions are of an organic or sexual origin, and their social relations, and the habit of dependence, which they have inherited, upon these relations, we must admit that the moral elements of crime are so strengthened as to modify materially their deficiencies of strength and want of opportunity.

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[1] Quetelet, *loc. cit.*, p. 91.

Many of woman's social relations are well calculated to clear and make easy the way to crime. It is another confirmation of the fact that society prepares the crime, and the criminal executes it. Compensation is found for her in the fact that society also places obstacles in her way by removing many temptations and opportunities for offense. But, in those crimes which are the natural outgrowth of her sexual and social relations, we find woman standing upon man's own level as a criminal. Thus, in infanticide and in poisoning, both of which, from the degree of offense involved, show a strong action of the exciting cause, all sexual difference in numbers disappears, and it is evident that the tendencies to those two crimes are equivalent in the sexes.

As the preceding shadows forth the interesting fact that woman, as a criminal, is under forces of both restraint and non-restraint other than sexual differences of mind or body, compared to man, it will be necessary to refer briefly to the nature and extent of these modifying circumstances, in order to appreciate the true bearings of the question. These conditions spring mainly from her social relations. This leaves us another important class of modifying conditions which may be traced to sexual relations. Two classes can therefore be made: (*A*) social conditions, and (*B*) sexual conditions, modifying woman's relation to crime.

The first (*A*) which exist sufficiently near to the subject to call for analysis are: (1) occupation, (2) opportunity, and (3) marriage;

and each of which must have a marked influence on sporadic cases of crime, and especially upon the creation of the criminal habit. But, much as these modifying circumstances have to do with the question before us, yet returns involving these particulars are so imperfect that we are able to get but a hint of the extent to which each acts.

(1.) Occupation, as it places woman above temptation to the minor degrees of crime, or as it brings her more closely in contact with constantly-recurring temptations, becomes an important factor. It is evident that these conditions must exist in the lives of both sexes, and have their influence on the frequency of crime and the nature of the offense. Thus in an official return [1] quoted by Quetelet, in which the offenders are classified by occupation, the accused of the eighth class who all exercised liberal professions, or enjoyed a fortune, are those who have committed the greatest number of crimes against persons; while eighty-seven hundredths of the accused of the ninth class, composed of people without character, as beggars and prostitutes, have attacked scarcely any thing but property. When the accused are divided into two classes, one of the liberal professions, and the other composed of journeymen, laborers, and servants, this difference is rendered still more conspicuous.[2] This is sufficient to render the broad inference probable that want or necessity induces but the minor degrees of crime against property, while the more serious phases of crime belong to the opposite conditions of society, or have their mainspring in other motives. In the *Compte Général de l'Administration de la Justice*, the occupation of the accused is given by sex, and under the article *Domestiques* we find one hundred and forty-nine men and one hundred and seventy-five women employed as personal servants, nearly all of whom were accused of the minor degrees of crimes against property. These proportions for this occupation hold about the same relations from year to year. As persons so engaged are maintained generally by their employers, want could not have existed as a motive for these offenses. Cupidity, or the desire to appear well, with the facility of its gratification, afforded by occupation, is the probable motive, and, making allowance for the slight excess of women so employed, exists in almost equal intensity in both sexes.

From what we know of the inadequate pay attending many of the employments in which women are engaged, it is safe to say that irresistible temptation is often the result. In the larger cities there are thousands of women, reaching from youth to advanced life, who are but just able to provide themselves with the necessities of life by labor extending over more than half of the hours in the day. Many of these have others dependent upon them, which must add very much to the tendency to the minor forms of crime. But the tendency to crime arising from inadequate pay is twofold. It may not be sufficient to meet necessary bodily wants, or barely sufficient, or, as is too generally the case, it is insufficient to supply those matters of personal adornment and comforts of surrounding, small as many of them are, which are so necessary to contentment. This tendency to adornment either in person or surroundings must be looked at seriously as a sexual mental trait in women. They need but to reach the rudimentary stage of education to have developed in them æsthetic tendencies, and which in many seem to exist innately. This feeling is also closely allied to that personal pride which is such a safeguard against the encroachments of vice. This pride of person is to many a struggling woman what a moral atmosphere is to others. To the one it is an instinct which keeps her from the degradation, and that conduct which leads to it; to the other it is the moral force which surrounds her and lifts her above the opportunities for evil. Viewed in this light, personal pride, as expressed in the adornment of person and home, may replace the purely moral sense to a certain extent. But pushed beyond the point at which it contributes to correct conduct, and allowed to exist solely as a sexual trait, it may become a strong incentive to crime. There is no reason to doubt but it is mainly the cause which makes crimes against property so nearly equal in the sexes among French domestics just alluded to. A mere desire for luxury would not be liable to develop in one never at any time of life exposed to its enervating influence, as the mass of working-women spring from parents who are also toilers, so that we may safely conclude that want, or a personal pride to appear better than others in the same station, is the most active cause of crime among underpaid women who have inherited no criminal taint.

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[1] "Rapport au Roi," 1829.

[2] *Loc. cit.*, p. 85.

The massing of large numbers of women at manufacturing centres is a circumstance from which spring many conditions which render the minor degrees of crime easy of commission. It is a singular fact that a great preponderance of numbers in one sex over the other, unrestrained by ties of family, and without the natural dependence of the different occupations and stations of life upon each other, almost invariably defines a locality in which the various forms of crime exist to excess. This has long been remarked of places in which the number of men greatly exceeds the number of women, but little attention has been called to the same condition as resulting from the preponderance in numbers of the other sex. Any one who has inquired into the causes of the social evil must have been struck by the numbers who admitted they had taken the first steps of their career in the populous manufacturing towns where an excessive number of their own sex was employed. There is this marked difference: an excess in the number of men leads to an increase of crimes against persons, while an excess of women increases crimes against property, in both cases relatively as to sex. I see no way, in our present knowledge of the subject, of explaining this, other than that a healthy tone of society demands an even balance of the different occupations and stations, and the presence of those ties of kinship which act so powerfully as restraints. Aside from these conditions I know of no facts which show that an even proportion in numbers of the sexes has a mutually conservative effect upon morals.

Generally, those in whom there is no inherited criminal taint, or no development of the criminal habit, would not seek nor create an opportunity for offense. But this can hold true only as to crimes against property, for in the other class of offenses, revenge, jealousy, avarice, and other emotions, may act suddenly as the exciting cause.

It is evident that woman's opportunities for crime are restricted by her relations to society, except, as we have already seen, certain facilities are afforded by her occupation. The moral influence of woman upon society is powerful; but it is negative rather than positive. Woman wields a sort of moral inhibitory power. Except as she may directly incite the other sex to crime, relationship to woman restrains and tones down the more salient points of the male character. Her lessened opportunity for crime results naturally from her sexual relations. Opportunity springs from the free mingling of large numbers in the heat and action of life. It is the antagonism between interests and objects, the friction, as it were, between the rapidly-moving actors, which brings out the intensity of emotion which results in the open or secret warfare of society. The vast majority of women are, to a certain extent, removed by the restraints not by any means artificial, but those which naturally result from their sexual relations, from the opportunity for crime. But I would limit even those restraints to crimes against property, rather than against persons. Although the ratio is sixteen and thirty-two to one hundred for each of these classes respectively, yet I believe it can be shown that the diminished ratio for crimes against persons depends upon other and more specific causes than her sexual attitude to society. Domesticity in this relation shows its potency as a conservator of morals; but, standing alone and unaided by mutual dependence and interest, its power is limited to placing each subject beyond the more closely-besetting opportunities to which men are exposed. It is but necessary to call attention to the fact that it is from among female domestics and operatives that the ranks of prostitution are recruited, in order to show that domesticity, which is the condition of seven-eighths of the female population, must be accompanied by other relations in order to act as a more or less complete restraint to crime. I use the word here in its broadest possible sense, as defining the position of the majority of the sex. Great as the influence of the domestic relation is, it is limited by the fact that it is not permanent. It is constantly exposed to those accidents to which all human relations are liable. The passions and discordant interests find in this relation a field for their utmost activity. The sexual relation, which is founded in the passions common to us all, finds in them the elements of its strength and permanency, as well as its weakness. It is created and made lasting as life, or as brief as a summer's day, by one and the same organic emotion. Otherwise marriage, which we may assume as the type of domesticity, would not seem of itself to exist as a factor in crime. As we study marriage in relation to crime in another part of this paper, we shall perceive some very singular facts in which its bearings upon society are not so healthy as might be expected. It cannot be charged, however, to marriage, which is the most perfect of all human relations, but to its underlying weakness, the changing sexual conditions upon which it is based. It is safe in a broad grouping of crime to say that the emotions and passions define offenses against persons, while those against property are characterized by processes of mental calculation and deliberation. The last needs opportunity and temptation; the first exists everywhere. The domestic relation affords a refuge to the one, and contains within itself the element of the other. For these reasons I believe that the restraint afforded by domesticity must be mainly limited to crime against property.

In connection with this division of our subject we are brought face to face with the fact that women are as capable of crime as men. "It is not the degree of crime which keeps a woman back," says Quetelet . . . . "Since parricides and wounding of parents are more numerous than assassinations, which again are more frequent than murder, and wounds and blows generally, it is not simply weakness, for then the ratio for parricide and wounding of parents should be the same as for murder and wounding of strangers." [1]

With opportunities equal to man's, with the way to crime made easy, instead of being hedged in by the limits of her occupations, woman may equal him in the tendency to crime. Infanticide, in view of the strength of woman's maternal emotions, of the acuteness of her sympathies, and the general attributes of her character, stands alone as a crime in its relations to the sex. Considering the violence done to emotions which are a part of her organic psychical life, it has no equivalent in degree in the range of crime. If we apply to it the theory that the degree of offense, to a certain extent, affords a measure of the tendency to crime in the individual, this crime would reveal in women such a tendency greatly in excess of the other sex. But we must bear in mind that this crime, more than any other, which tends to make woman appear unduly prominent as a criminal, is a natural outgrowth of social surroundings. It is a marked instance of the fact that society contains within itself, even in its normal conditions, the moral agencies that create crime. Society has raised for itself a gauge of conduct, by which the alternative may be presented to any woman, of either crime or disgrace. At the same time society has so organized itself that the chief aim of every woman has been to establish a permanent relation to some man based upon involuntary sexual emotions. So long has this been in existence, so much power has it acquired by the increment of the forces of heredity, that it has become an organic law of society. This is a factor which enters into every woman's existence; by it her sexual life is made to exceed in intensity the intellectual. Ceaseless indwelling upon what every woman is taught to regard as both a necessity and an honor has tended to give undue force to every thing that relates both mentally and physically to her sexual existence. This is the manner in which society has made the way easy for woman's sexual error. Reflecting upon this, I confess to admiration for a sex which in the face of these difficulties has ever maintained such a well-deserved reputation for purity, and shown us that mankind turns instinctively to good rather than evil. Punishment is part of the crime, with society. To women for a sexual offense it measures out a punishment relentless and life-long. They are banished and hang on the outermost skirts of the inexorable law-giver as "Scarlet-Letter" ones, for whom, in all their lives, there is no further hope.

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[1] *Loc. cit.*, p. 91.

Prepared in this fashion for infanticide, can it be wondered at that the ratio for this crime is 1,320 women to 100 men?[1] It is clearly an alternative of either social banishment and a total defeat of her selected destiny, or an attempt to conceal her error by crime. With an obliteration of one set of moral feelings there must be necessarily a weakening of the general moral character. She is therefore prepared to violate all the emotions and consciousness which have their origin in the very condition, through the undue development of which she met disaster. Infanticide appears to the woman's consciousness less formidable and repellent than her certain punishment by society. Her training has prepared her to place this lessened value upon the crime. Quetelet gives prominence to shame as an impelling motive to the crime. I can give it no such value. That sense of shame or modesty which exists as a phase of sexual cerebration in every mentally healthy woman, and that induces her to guard so jealously the casket after the jewel has been stolen or rather bestowed, is the part of her mental life to which the most violence has been done by her social error. What the French philosopher ought to refer to, is not the sexual quality of shame, but a sense of degradation which is common in an equal degree to both sexes. It is the sense that the good opinion of those we know, and whose esteem we value, has been forfeited. When we connect this sense of forfeiture with the fact that the interests in life which women are educated to hold most sacred, await but detection to be lost forever, I think we have found sufficient reason why this crime, which so antagonizes all womanly qualities, should exist to such a degree as to alter nearly one-half the ratio of the sexes in relation to crimes which involve human life. In ana lyzing the circumstances which bear upon infanticide, we are studying the darkest page of woman's criminal history. It proves that under a sufficient motive, and with every opportunity which her peculiar relation to that offense gives, she demonstrates her capacity to equal man in both the degree and number of her criminal acts. It is, however, an offense so characteristically entwined with her sexual life, and with her relations to society, that we must have a due regard for circumstances in contrasting it with any crime or series of crime in men. As already perceived, I am disposed in this inquiry to assign it but one value: her disposition to entertain the criminal idea, and under favorable opportunity to give that idea expression. In other respects the crime stands alone, and can be used only in contrasting woman against woman. There are certain abnormal states of sexual cerebration connected with this offense which will more readily present themselves when we study the crime against society—the social evil.

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[1] Quetelet, *loc. cit.*

In considering the effect of married or celibate life upon women in relation to crime, we are beset by many difficulties in regard to data. The officials upon whom devolve the duty of collecting criminal statistics, have yet to learn that they deprive their labor of much of its scientific usefulness by their errors of omission. The information has but little value that so many male or female criminals are married or unmarried. A proper study of the subject requires that this information be given in its relation to crime as it affects persons or property, the age at which the criminal career began in the two classes respectively, and crime among the widowed or divorced. Nearly all these facts are wanting. We can, however, collect sufficient data to enable us to shadow forth the probable truth in regard to this important matter. We may safely term marriage the unit of force in our present civilization. I have briefly called attention to its innate strength and weakness, which are inseparable from human mutability. It is easy to perceive the manner in which marriage may act as a conservator of morals, and its operation as a promoter of crime is equally evident; but the extent of its operation in either direction is difficult if not impossible to measure. In the examination of the returns of crime for the years 1867, 1871, and 1873, in New York City,[1] and which show great uniformity in the social condition of the sexes, we are met with the strange fact that the percentages of the married of both sexes correspond, being thirty-nine per centum; while for males the percentage of the unmarried is fifty-five, and for females in the same social condition it is forty-two. Regarding marriage as a conservator of morals in its affirmative rather than its negative relation, this statement places man on a level with woman; but observing further that the excess of male criminals is furnished from the unmarried, and that the single and married female criminals exist in nearly equal proportions, we can reach but one conclusion, that marriage exists as a restraining influence against crime more strongly among men than women. I think this result is opposed to the preconceived opinion of the majority, of the effect of marriage upon women. Marriage for women has ever been regarded as a preliminary condition to reform. This is the result of the sentimentalism which has entered into the solution of many social problems. Marriage is not unmixed good. Lecky says of it, that "beautiful affections which had before been latent are evoked in some particular forms of union, while other forms of union are particularly fitted to deaden the affections, and pervert the character."[1] Woman's keenly emotional nature is well disposed to be exalted or depraved by marriage. It seems hardly possible to reach the true causes of the nearly negative results of marriage upon the morality of women by a study of the character of this sex alone. In women, rather than men, are mirrored the lights and shadows of society. Mentally she is the plastic material which takes its form from the protean phases of life around her. She is spiritually the resultant of her moral atmosphere. I believe these influences are more potent in forming her character than man's, from the nature of her dependent circumstances. With man's opportunity for objective life, he can remove himself, partly at least, from the moral surroundings; and by identifying himself both bodily and mentally with labor, which has for its object, usually, something to be attained in the future, he has loop-holes to escape from impressions received from others, which with a more subjective life would result in introspection, by which the mind is familiarized with the criminal idea.

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[1] Table "B," 23d and 27th, and Table "A," 29th, "Annual Reports of the Prison Association, State of New York."

From the same source we may gain additional facts as to the negative effect of marriage upon the morality of women. In the tables referred to, involving in the aggregate an excess of males over females of about two to one, we find the number of widowed females over males in the same social state to be nearly double. It is impossible to state specifically the nature of the crimes involved in this excess; but it probably represents, in a great measure, offenses against property. The social condition of widowhood in the average woman is not conducive of morality; and yet we have already shown that actual marriage is attended with nearly negative results. From this we may gain an idea of the extent to which women are the victims of circumstances at the beginning of their criminal career. The figures we have been analyzing represent crime in a great city. Under this condition, the excess in the number of widows represents probably cases of complete destitution. The fact that this excess of widows had no means of coping with this difficulty, except by a resort to crime against property, renders the conclusion safe that not only marriage had not developed in them a condition favorable to morality, but had actually so lowered the moral tone as to render them unfit, as a class, to contend with the difficulties of life, and exhibit the same degree of morality as the unmarried woman. Much of this result must depend upon the unavoidable social position of the married woman—one not at all calculated to test either her morality or self-reliance. The duties of maternity and domesticity inseparable from her position, do not fortify her against evil in her changed relation to society. On the contrary, with the burden of children upon her, in the time of need, she looks upon crime less as a positive than as a comparative evil. With the true woman, there is no chance for hesitation in the choice between crime in its minor forms and her maternal feelings. But the marriage relation has other influences in forming woman's character as a criminal. The intimacy of the wife with a bad husband, who, if not a criminal, at least may be capable of infusing lax moral notions in the wife, would, if she were left a widow, surely bear fruit. We need a more intimate knowledge of many facts in order to fully understand this question of widowhood in its relation to crime. It is doubtful if returns of crime from less densely populated places than New York City would furnish results at all parallel to those in relation to widows. The most plausible explanation I can give is, that these figures represent cases of absolute destitution.

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[1] *Loc. cit.*, vol. ii., p. 369.

There are many other relations that marriage bears to woman's career as a criminal, but which are beyond the scope of a magazine-article. All that relates to infanticide, and the prevalence of the crime of the period, among the single and married, ought, I believe, in writings of a popular character, to be omitted, except possibly the grave words of warning. Upon this subject I have written all that I thought prudent several years ago, and to which I refer the reader.[1] The well-known lines of Pope upon the effect of familiarity with vice, are certainly very true to-day. It is by a too familiar view of even the shadow of crime, that in certain minds the criminal idea may be developed. We need but abolish the mental barriers to crime to step from the criminal idea to the criminal act.

Instinctive recoil from the criminal idea without any mental reservation is the characteristic of moral health. It is upon the morally healthy minds that unfavorable social conditions may have most deplorable effect. One in whom the tendency to crime exists as a latent mental quality, requires no social conditions for its development. Whatever his or her occupation or social condition may be, this latent quality is liable to assume active existence, and shape the destiny of the individual. There is one quality that the criminal exhibits which defines him as a class, and is the only trait by the existence of which he becomes the member of a class. This is the liability, after the first outbreak, to commit repeated offenses. I find no term which expresses this so well as that of the criminal habit. Mentally and physically we are the victims of custom. Existence, like running streams, has a tendency to find for itself fixed channels. Life as it expands seems to seek points of least resistance for its outlets, and in following which it encounters less friction to retard its flow. In relation to crime, this exists as strongly as the opium or alcohol habit. The habit may find its factor in perverted moral feeling, whether hereditary or acquired, but its physical expression becomes the rule of life. Take such an instance as that of Ruloff, to whom Nature had given the crude material of a magnificent mind. In spite of the terrible potency of his criminal ideas, a longing for a nobler and higher life existed within him in sufficient force to give direction to considerable self-culture. He stole, and would kill without remorse any one who stood between him and his object, simply to gain money to enable him to follow his studies. His life took the direction of the least resistance. That which existed in the normal man as a sense of right or wrong, and offered itself as an obstacle to wrong-doing, had no place in this man's mental life. The outgoings of his life in the direction of least resistance, simply and naturally led him to crime. Cerebral and bodily activities, among the good and bad alike, follow the channels in which they encounter the least friction, either objectively or subjectively. It is thus we have the parson and the thief. By inherited traits, early training, occupation or social condition, weak points may be created in the barriers which surround the activities of life, and when maturity is reached the individual's existence is defined by ineffaceable lines. At this stage of life, efforts, made either from within or without, to give a new direction to these channels, come too late. Habit has been established which confirms the direction life has taken. These two forces united seem irresistible. I was, several years ago, brought in contact with an instance which proves this. Lena S—— was of German descent, and about fifty years old. She was of more than average intelligence, and of spare, nervous temperament. Lena was an instance of sporadic crime, in the sense that she did not belong to a criminal family. She followed the specialty of shoplifting, one that requires great coolness and cunning. Caught in the act and arrested, her history was brought out. She was married, and her husband was serving out a term of imprisonment, but with whom she had not lived for many years. She wandered from city to city, following her business; she had been repeatedly arrested, and more than once punished, and every time her whereabouts was brought to the knowledge of her family by her arrest, attempts were made to reclaim her, but in vain. Sentenced to several years of imprisonment, she quickly began to droop. She passed sleepless nights, with quick, irritable pulse, and loss of appetite. She constantly brooded, and laid more than one plot to escape, one of which was nearly successful. Out of about a year and a half of confinement, not more than a month of light labor was exacted of her. Her health became so broken that, at the earnest solicitation of her relatives, the prison authorities took the case up, and secured her a pardon on condition that she left the State, and her relatives provided for her. But the transition from prison-life to the comforts of a home, and a life of ease, offered no attractions to the unfortunate woman. I believe she remained under the care of her relative—a devoted sister—but a few months, when she resumed, out of choice, her old mode of life, and is now serving out another sentence.

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[1] "The Detection of Criminal Abortion, and a Study of Fœticidal Drugs." James Campbell, Boston, 1872.

This case shows how irresistibly the deliberate acts of life flow in the channel which habit and mental traits mark out for them. The barriers which society, and fear of punishment, and love, place in the way of a career like this of Lena S——, are swept away, as it were, before a flood. This is the destiny of the fatalist, and the force of habit, an expression of the theory of least resistance, and the effects of heredity of the sociologist. Let us analyze the last case further, to illustrate the theory of least resistance, as modified by occupation and social condition. It presents a seeming contradiction. She moved on in her career of crime late in life, with her moral atmosphere charged with resistance to her progress. Contrasted with this was her criminal pupilage in early life. Her husband united pauperism and crime, and if originally her moral perceptions were clear—which I doubt—she thus found the best school to obscure these, and familiarize her with the criminal idea. With these faculties blunted and weakened, which serve to hedge in the impulses to evil, she proceeded to supply her wants by the method most familiar and easy. The thief looks upon the property of others in a peculiar way, and one that constitutes the essence of the crime. He believes in a sort of ownership which is mutual, and depends upon possession. This belief may become a fixed habit of mind. Originally it may have been easier to steal than to work, later it may become more impossible to work than to steal. Then came attempts at reform, made by others, with the life of ease and comfort, but the criminal grew wretched and drooped. There was but one life before her which met the demands of her nature—that was to wander from place to place and steal. This woman answered in no sense to the legal definition of the insane; she was not irresponsible for her acts, she knew their nature and the punishment which followed detection; but she simply did that which the most of us desire to do, follow the easier and pleasanter life. It has become the fashion of late to speak of criminals of this class as insane, but this theory cannot explain their irreclaimable condition. The real state, as it appears to me, is, that thoughts and acts move in the direction of least resistance. What began in this way, may be confirmed by habit, so that life may wear for itself channels from which it is impossible that its current may be driven.

HYDROIDS.

By Mrs. S. B. HERRICK.

SOME of the most exquisite forms of organic Nature are to be found in that shadowy border-land which unites rather than divides the animal and vegetable worlds. It is hard to believe, even when looking with careful scrutiny at certain forms of animal life, at the corals, for instance, the sponges, and the hydroids, that an existence which so closely resembles vegetation should be essentially ani-

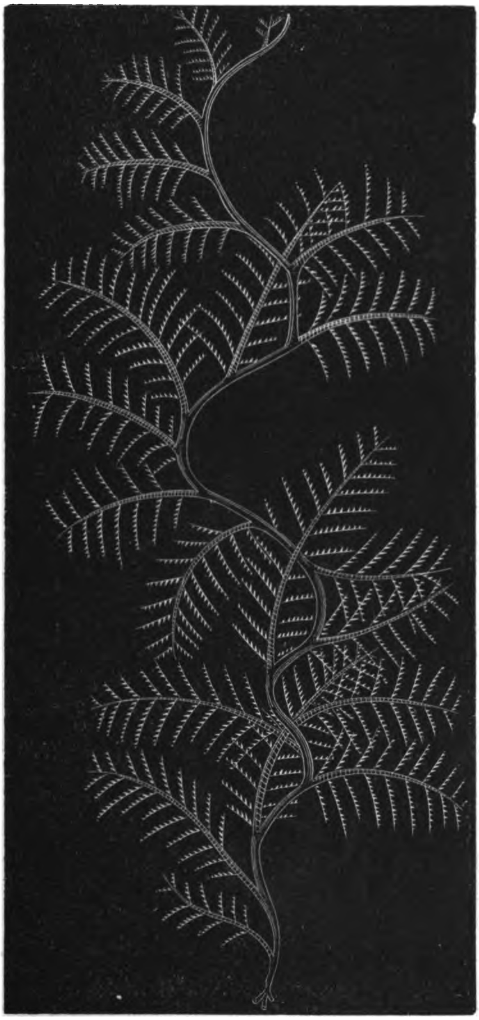

Fig. 1.—Plumularia falcata. (Natural Size.)

mal. Each of these families of the great invertebrate kingdom has been bandied back and forth from the botanist to the zoölogist, and each has finally found its place in the animal world.

No purely empirical knowledge is sufficient to determine, among the lower forms of life, to which kingdom they should be referred. It is only by studying facts in their relations, by patiently observing the life-history, and by ascertaining the modes of nutrition and reproduction of each form, that its true place in the organic world has been determined.

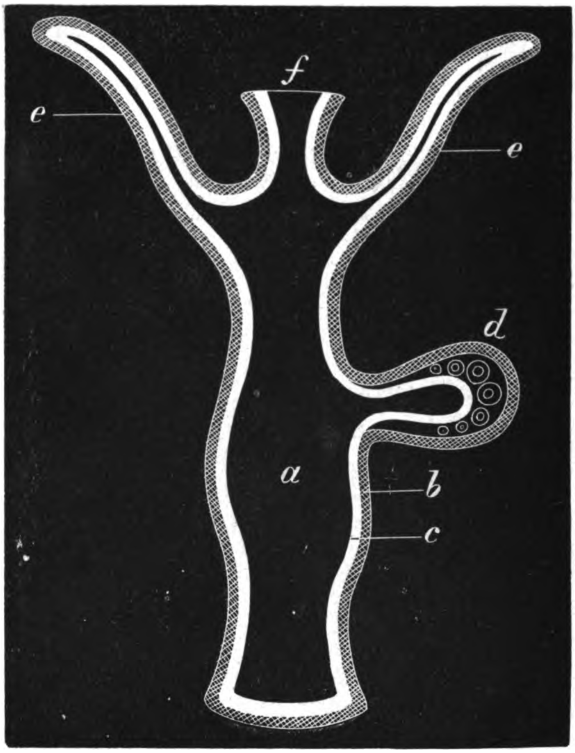

Fig. 2.—Diagram of a Section of Hydroid.

It was, for many years, thought that, beyond the depth of 300 fathoms, organic life ceased to exist in the ocean. Forbes reached this zero of life in the Ægean Sea, and the fact ascertained for the Mediterranean was inferred for all other seas. The transmutation of inorganic into organic matter is only performed by vegetables, and then only under the controlling power of light. The distinction made by naturalists between the lowest forms of animal and vegetable life lies just here: vegetables convert the inorganic elements of earth, air, and water, into organized matter; animals rearrange this organized matter into animal tissue. It is well known, as no light penetrates the profounder oceanic depths, that no vegetation can exist there; an absence of animal life was therefore inferred. Certain exceptions to this definition of vegetable life, as being exhaustive, are found in the *Fungi*, which germinate and grow in darkness, and it is believed are nourished in great measure by organic matter, as well as in the curious carnivorous plants, which have of late attracted so much attention. This, however, does not invalidate the truth that all nutriment, in order to be fit for the maintenance of animal life, must pass, at least once, through the transmutation effected only by vegetation.

The non-existence of life below 300 fathoms, in all the oceans of our globe, was strongly supported by Forbes's investigations in the Mediterranean. The abyssal depths of the sea were thus determined by logic to be the universal empire over which reigned darkness, desolation, and death. No investigations were made as to the facts of the case. Logic and a hasty generalization from inadequate knowledge were made, once again in the history of science, to do duty for the more laborious method of patient observation. Commerce at last gave the impulse to deep-sea exploration, which had before been lacking. The commercial world demanded a more speedy mode of communication from continent to continent, and the response came in the form of the submarine telegraph. Thousands of soundings were made to determine the best position in the ocean's bed for its successful laying, and thousands, again, to secure the broken end after the

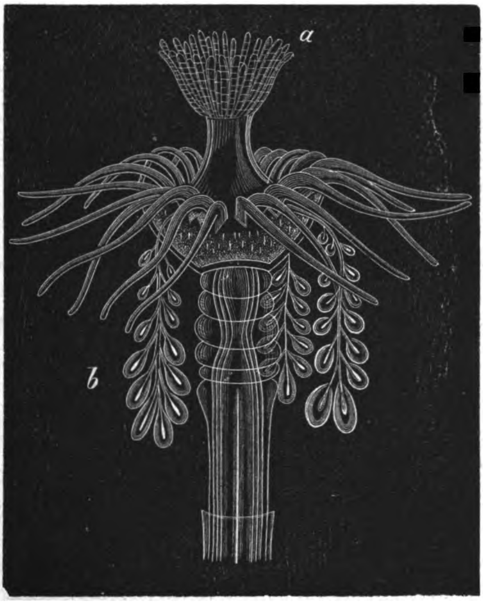

FIG. 3.—NUTRITIVE BUD OF TUBULARIA INDIVISA. (From Male Colony.)

first failure. These soundings and grapplings brought from the sea-depths unmistakable proof that life in many varied and exquisite forms existed there, far away from light and vegetation, under an enormous pressure of superincumbent waters; and logic retired discomfited.

The fact that the Ægean Sea is empty of life in its greatest depths is due to local causes. The humblest life, in the farthest recesses of the ocean's bed, is, in some of its essential features, but a sluggish copy of the higher types on land. Food and air are alike necessary to both. The circulation of currents throughout the open seas bears nutriment and oxygen to the lowly forms of animal life which lie far below the level penetrated by light, or capable of supporting vegetation. In the Mediterranean such currents are obstructed by the high rocky wall which runs under the straits of Gibraltar, from Spain to Africa. The lowest point in this wall is 10,000 feet above some portions of the bed of the Mediterranean. The currents in this sea are therefore superficial, as well as the life sustained by them.

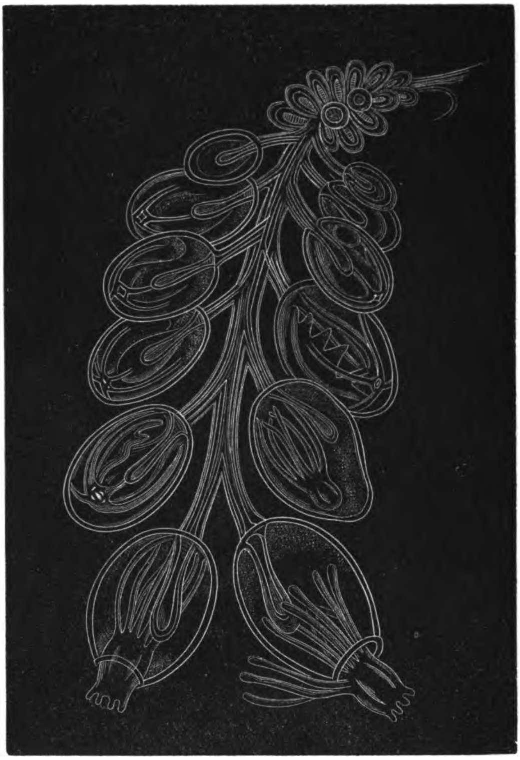

FIG. 4.—GENERATIVE BUDS OF TUBULARIA INDIVISA. (From Female Colony.)

Chemical analysis proves that the water of the open seas contains both organic matter in solution and oxygen; and that this same water, after having passed through the bodies of these lower forms of animal life, is deprived of both its organic elements and its oxygen. The theoretic difficulty which had determined the problem of life in the depths of the sea was thus removed; for, given this lowest form of animal existence, the higher are always possible.

The same awful cycle of life, death, decomposition, and life again, which is again and again repeated among the higher organisms, is found working itself out as inexorably in the oceanic depths. The elements which are appropriated from the mighty reservoir of the ocean for the maintenance of the life, are restored to it again by the death, of each organic being.

The bed of the ocean, from the tiny lakelets left by the retiring tide to the greatest depths ever reached by trawl and dredge, is found to be teeming with exquisite forms of life. Delicate plant-like forms are found clinging to rocks and shells, or spreading themselves over the broad fronds of the algæ. Every peculiarity of vegetation is mimicked; graceful stems rising from tangled roots send out branches which bear raceme-like clusters of buds, and delicate bells whose beauty no words can describe.

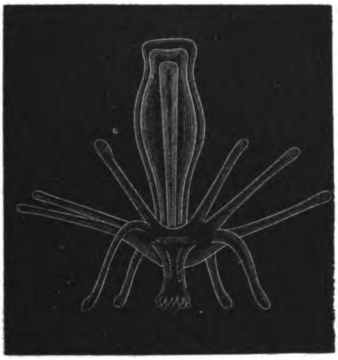

Fig. 5.—Roving Medusa of Tubularia indivisa. (Magnified.)

A hundred and fifty years ago nothing was known of these beautiful hydroids. The first investigation deserving the name was made by Abraham Trembley. This man was born in Geneva in the year 1700. While residing at the Hague, as tutor to the sons of Count de Bentinck, he made a series of remarkable observations upon the fresh-water hydra. The results of his observations were published first by Réaumur in 1742, and two years later by himself. In 1727 Peysonnel had paved the way for Trembley by proving the animality of the corals. Jussieu visited the coasts of Normandy to investigate the coral question, after Peysonnel's publication of his views, and there conclusively demonstrated the animality of *Tubularia indivisa*, one of the loveliest of the hydroid family. The hydroids are among the coral-makers. The vast beds of millepores found about the Pacific islands and the West Indies are the work of an animal allied to *coryne*, one of the Tubularians. The chitinous investment of the Sertularians also forms membranous coral of considerable size and great beauty. It was some time, however, after the discoveries of Peysonnel, Jussieu, and Trembley, before the great authorities of the day, Réaumur and Linnæus, gave in their adhesion to the animal theory, and stamped it as correct. Since that day some of the world's greatest naturalists have made the study of the *Hydroidæ* their life-work, and have not felt it an unworthy occupation to be the annalists of this humble family.

The nomenclature of the hydroids is still so unsettled that we will avoid as much as possible the use of scientific terms in describing the different portions of the colonies and their respective functions, for it is here that naturalists differ, not in the names of the varieties.

The hydroids measure from a few lines in height to several feet. Dana mentions an East Indian species which grows to the height of three feet; while Semper describes a gigantic *Plumularian*, which forms submarine forests extending over great areas of sea-bottom, and growing as high as six feet. The stems, he says, sometimes measure an inch in diameter at the base. *Tubularia indivisa* grows to the height of about ten inches.

The *Hydroidæ* are divided into four families: *Tubularinæ* (Figs. 3, 4, 5, 6), *Campanularinæ* (Fig. 10), *Sertularinæ* (Figs. 1, 7, 8, 9), and *Hydrinæ* (Fig. 12).

Every hydroid, however greatly the species may differ in external form, has a certain structural plan to which it adheres in all its modifications. The general type (Fig. 2.) may be simply described as an animal sac whose walls are composed of an inner and outer membrane. The outer wall corresponds to the skin, the inner to the lining of the stomach, in higher organisms. The simple elongated sac is not only the simplest form of hydroid, but is generally the earliest phase in the development of the more complicated forms.

The sac (Fig. 2) sends off branching processes, *e e*, and cœcal protuberances, *d*, throughout the extent of which the inner and outer membrane is continuous. Sometimes large numbers of these stems proceed from a basal net-work, the connection between every part of the animal colony being kept open through this basal reticulation, and the continuity of the two membranes being maintained intact. The basal portion, with the stems, branches, and the flower-and-fruit-like clusters, of this curious organism form the *hydrasoma*, as it is called by both Huxley and Allman.

The simple, sac-like form of the hydroid is the lowest term in a series which consists of an almost infinite number of terms. We find in this family the same orderly sequence which marks organic Nature everywhere. While the ideal type is adhered to, and a morphological unity may be proved, yet there is an orderly and beautiful gradation, in which each form becomes more complicated than the form which precedes it.

The clusters of buds (Fig. 4), and closed or open flowers (Fig. 3), are really individual zoöids, bound into an organic unity by a basal reticulation. With a single exception, every hydroid, at some period of its existence, lives this social life, being united with a number of other individuals into a plant-like group, and is really only one of an assemblage of zoöids possessing a common circulatory and nutritive system, the individuals of which are in organic union with each other.

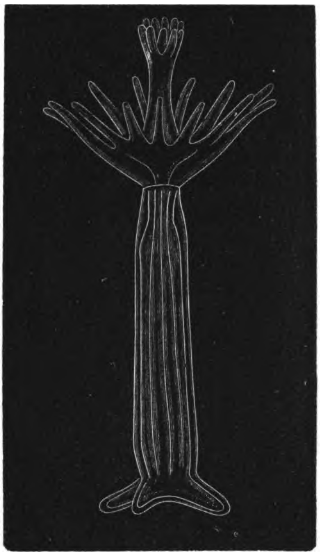

FIG. 6.—MEDUSA OF TUBULARIA INDIVISA. (After it has permanently fixed itself.)

The zoöids springing from one common base are of two kinds, and perform for the community two special offices. The grape-like clusters contain the generative elements, both ova and spermatozoa, while the flowers provide for the nutrition of the whole colony. These zoöids, which each investigator names according to his peculiar theory of scientific nomenclature, we will call nutritive and generative buds; the nutritive buds being destined for the preservation of the colony, the generative for the perpetuation of the species. The attached extremity of the animal in the fixed, or its equivalent in the free, species is called the proximal end, and the opposite extremity, which bears the two forms of buds, the distal end of the hydroid. The terms upper and lower cannot be used, because some varieties grow erect, while others grow in an inverted position.

The nutritive buds consist of an open digestive sac (Fig. 2);

around the mouth is a series or several series of tubular offsets, ranged radially about the stem. The shape of these blossom-like zoöids varies in the different species. In some varieties they are unprotected, while in others the tentacles may be withdrawn into a horny, cup-shaped sheath. The number of tentacles varies with the different species. The plates of *Tubularia indivisa* and *Hydra vulgaris* show the tentacles expanded. The other plates give, in the magnified portions, only the chitinous sheath, into which the polyp has withdrawn itself.

In the Plumularians, a branch of the Sertularian group, curious little cups of the horny sheath are developed. Unlike the cups which contain the living flower, these extensions are filled with the sarcode, or soft, gelatinous flesh of the animal. This sarcode, or protoplasmic flesh, acts like the flesh of the rhizopods and amœbæ; long filamentary processes are extended, just as the rhizopods improvise legs or arms when they need them, till sometimes the horny sheath is invested in this living gossamer. The function of these cups is not known. Allman considers them as special zoöids, whose morphological differentiation from the other zoöids is carried to an extreme. Hincks believes them to be a lower form of life, in organic union with the higher zoöids of the hydroid colony.

The horny sheath, which is described by earlier writers as an excretion, is by Allman considered to be rather the result of metamorphosis of tissue. In many varieties the stem and branches of the creature are slender, horny, and pipe-shaped, and the chitinous sheath is jointed at regular intervals, the joint being a mere break in the continuity of the chitine, not a movable hinge; while the living pulp within forms a continuous body, and is invested by its sheath as the pith of a plant is invested by its stalk.

The generative buds are cæcal offshoots from the body, the reproductive elements always developing between the inner and outer membrane (*see* Fig. 2, *d*). They sometimes, after development, free themselves from the parent stem, and lead a roving life as medusæ. In some cases the nutritive bud has its alimentary function suppressed, and, though not itself sexual, it is henceforth destined to produce sexual buds, either directly or through the medium of a non-sexual bud.

There is, it may almost be said, no differentiation of organs among the hydroids. In the adult form they possess no organs of sense, and have no circulatory, respiratory, nor nervous systems. All the functions of life are performed without the intervention of special organs. Voluntary motion takes place without muscles, sensibility is present without nerves, respiration is performed without lungs, and digestion goes on without a true stomach. The sea-water which flows within and about the creature bears to it the oxygen necessary to the maintenance of vital combustion, as well as the small living creatures and comminuted organic matter which form its food. Like the seaanemones, the hydroids reject such portions of their food as they do not assimilate through the mouth. In the fresh-water hydra an orifice has been observed at the lower extremity of the stomach. This, however, does not correspond to the alimentary canal of higher organisms; it is the analogue, in the simple hydra, of the ramifying cavity which permits a free circulation throughout the compound group.

A circulation has been observed in the varieties which possess a horny sheath, which is, however, very different in some respects from the circulation of the blood in higher organisms. The somatic fluid, as it is called, is loaded with granules which, upon microscopic examination, prove to be composed of disintegrated elements of food, of solid colored matter secreted by the walls of the somatic cavity, of cells detached from the living tissue of the animal, and of particles of effete matter. The fluid seems to be more nearly akin to chyme, or chyle, than it is to blood. There is perpetual motion in the somatic fluid; the flow will sometimes be steady for a while, and then a sudden reversal will take place in the direction of the current, before it has reached an extremity. The gastric cavity is traversed by the stream, as well as all portions of the hydrasoma. In some species the cause of the flow has revealed itself under the microscope. The cavities through which the current moves are seen to be clothed with cilia—tiny lashes whose rhythmic motion forever propels the fluid; this ciliary action is no doubt greatly aided by the contractility of the walls. In many species the cilia, if there be any, are too minute for detection; but it is a fair provisional inference that where

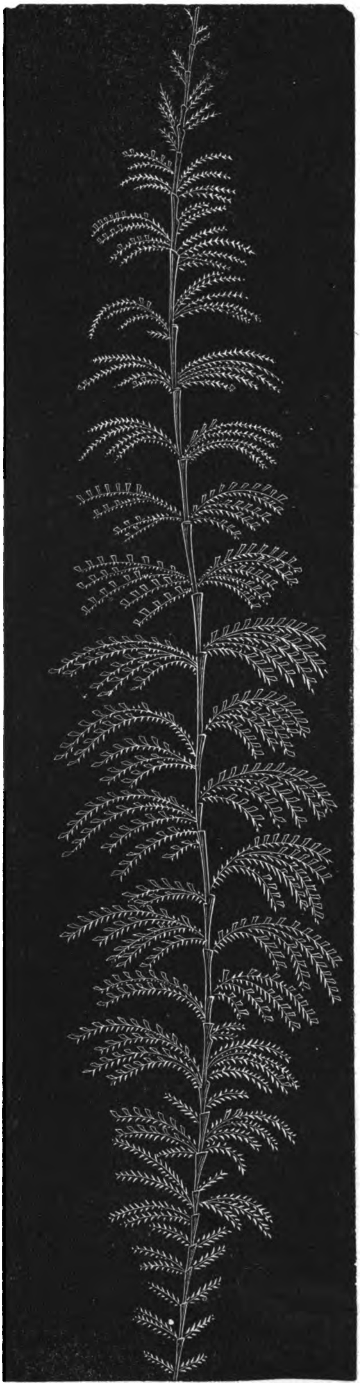

FIG. 7.—SERTULARINA CUPRESSINA. (Natural Size.)

the somatic flow is observed the like cause may account for the like effect.

The exquisite colors of the hydroids, which rival the tints of our loveliest flowers, are due to the colored granules secreted by the animal and discharged into the somatic fluid. A charm is added to these flowers of the sea by the flashing opalescent gleams of color which shine out from their crystalline walls. Even the exquisite representations of Allman, in his monograph on "The Tubularian Hydroids," fail to give an idea of the beauty of form and color to be found in the real object. The *Hydra viridis* is so called from its brilliant green color. This green is said by Allman to be of the nature of chlorophyll, and to possess the power, like the chlorophyll of plants, of decomposing carbonic acid, assimilating the carbon, and yielding up the oxygen. If this be true (and there is no reason to doubt it, Allman being one of the highest authorities), it only furnishes, in this form of animal life, one more curious resemblance to vegetation, and denies one more tradition of its animality.

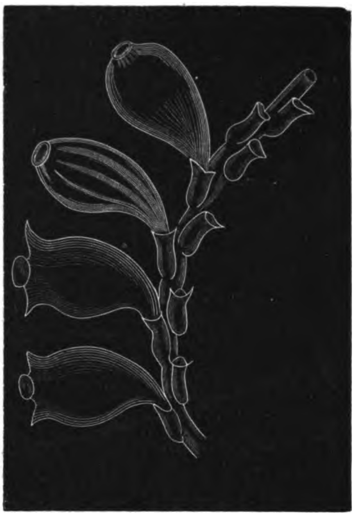

FIG. 8.—SERTULARINA CUPRESSINA. (Magnified.)

The most singular facts in connection with hydroid life lie in the variety of its modes of reproduction. It would almost seem as though every form of reproduction known in Nature had been mutely prophesied in the primeval world when the fossil hydroid and trilobite lived side by side in the Silurian seas.

They are generated, like plants, by buds and by artificial sections; like plants, they are able, from a small fragment, to produce the whole organism. They, however, go farther than most plants in this power of reproducing lost parts; for a small fragment taken from any portion will suffice for the production of a new individual; a single tentacle will produce a flower and stem, and finally a whole colony. A transverse section of the stem will produce a flower at the distal end, and a continuation of the stem, with the process by which it attaches itself, at the proximal end of the section. Just so far it shows orientation—that the stem has a distal and proximal end. There is no sign of bilaterality in most species, and in others the indication is so slight that it is hardly worthy of the name. This development of the flower always at the distal, and of the stem always at the proximal, extremity of the section, shows conclusively that the stem grows both ways, and that in every segment there exists a neutral plane midway between both ends.

Besides these plant-like modes of reproduction, hydroids are generated, like the actiniæ, by spontaneous fission, a development of one individual into two or more by a natural vertical cleavage.

They multiply by ova, by ovules, by independent ciliated embryos, like the lower invertebrates, the reptiles, and birds. Some varieties possess a sort of marsupial pouch, in which the undeveloped young are retained till they attain maturity; and, like the mammals, in some cases, the individual quits the parent after attaining perfect development. Added to all these modes of reproduction, in which the analogy must not be pressed too closely to those of higher organisms, they possess two very curious modes of their own; one given by Allman in his monograph, the other by Carpenter in the latest edition of "The Microscope, and its Revelations." The *Tubularian* and *Campanularian hydroids*, Allman tells us, develop upon their stems bell-shaped medusæ (Figs. 4, 5, 11), which free themselves and swim the adjacent waters. All free-swimming medusæ have not yet been traced to hydroid stems; but, as all which have been carefully studied through their life-history are found to originate there, it is supposed to be true of the others.

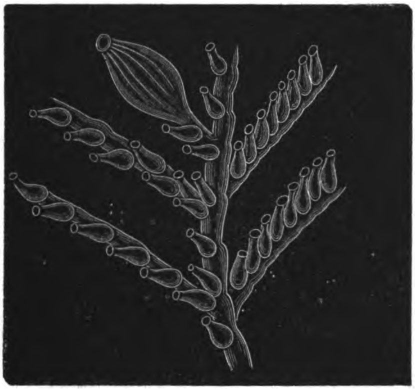

FIG. 9.—PLUMULARIA FALCATA. (Magnified.)

The most remarkable fact in regard to these medusæ is, that the immature form shows a higher type, a greater differentiation of organs, than the parent hydroid. The medusa possesses, in common with the parent, a digestive cavity and cnidæ; and, in addition to these, an organ at the base of each tentacle, which, if it does not unite within itself the senses of sight and hearing, at least is akin to those organs in the lower invertebrates. They certainly possess distinct bundles of muscles and nerve-ganglia, which are not found in the parent form. When the roving medusa has sown its wild-oats, and comes to settle down into a respectable family hydroid, it loses all these advantages belonging to its wandering life, and becomes in its later form identical with the parent; it returns to the privileges and traditions of its fathers.

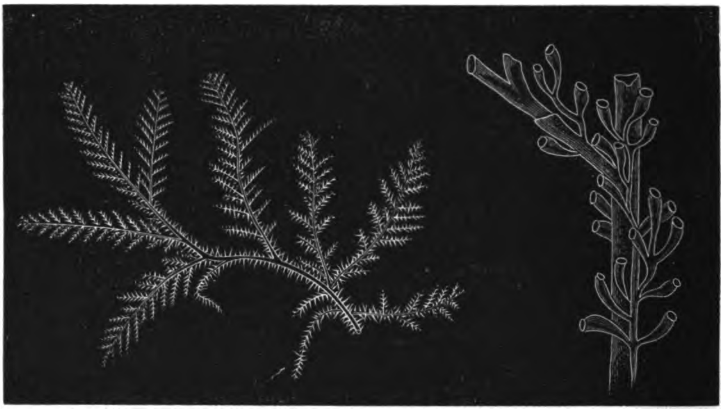

FIG. 10.—CAMPANULARIA DUMOSA. (Natural Size, and magnified.)

The huge *Rhizostoma*, and the beautiful *Chrysaora*, common to the English coast, Carpenter tells us, are oceanic medusæ developed from a small hydroid stem. The embryo emerges in the form of a ciliated ovule, resembling some of the infusoria. One end contracts, forms a foot and attaches itself, the other sends out four tubular offshoots, as tentacles, and "the central cells melt down to form the cavity of the stomach." This hydra-like form multiplies in the ordinary way by budding, for an indefinite length of time. After a while, however, a change takes place, the stem shows constrictions, beginning near the distal end, till the whole stem looks like a *rouleau* of coins; the constrictions deepen, making the stem look like a pile of saucer-shaped bodies; the disks become serrated, and finally the tentacles which belonged to the original medusæ disappear, and new tentacles are formed upon the uppermost disk of the pile. Soon this disk begins to show a sort of convulsive struggle which results in its freeing itself, and swimming away as a medusa; each disk develops in the same way, and in turn separates itself from the parent stem. The original zoöid often returns to its hydra-life and reproduces itself by budding in the old fashion, and finally becomes "the progenitor of a new colony, every member of which may in its turn bud off a pile of medusa-disks."

The bodies thus detached have all the characteristics of the fully-developed medusæ. Each consists of an umbrella-shaped disk divided along its margin into lobes, generally eight in number, and of a stomach terminating in a prosbosciform mouth. As the creature grows, the spaces between the marginal lobes fill up; from its border long tentacles are developed, and a fringe of tendril-like filaments sprout forth from the margin. The young medusa eats voraciously, and grows proportionately large; the *Chrysaora*, which we have been describing, attaining a diameter of fifteen inches, and the *Rhizostoma* sometimes reaching to three feet. These medusæ are familiarly known as *sea-nettles*. When they have reached full development the generative organs appear in four chambers arranged round the stomach, and are contained in curious fluted membranous ribbons which hold the sperm-cells in the male, and ova in the female. The fertilized embryos repeat the same wonderful cycle just described, developing into a hydroid from which medusa-disks are budded off.

The relation which late investigations have established between the stationary hydroids, and the medusæ, forms one of the most interesting cases, yet known, of the curious phenomenon called alternate generation. In the majority of cases we find a non-sexual, plant-like form interposed between the ovum and the directly or indirectly sexual form of medusa, though this is not always the case, as direct development has been observed from ovum to medusa.

The nearest approach, in the adult form, to special organs are the digestive cavity, and the cnidæ. The stomach, however, possesses no true parietal walls, and in one form—the fresh-water hydra—the stomach will do duty for the skin, and the skin for the stomach, if necessary; they seem to be able to live very comfortably, and digest their food without difficulty when turned wrong-side outward.

The cnidæ are barbed filaments inclosed in tiny sacs, which they can shoot out at will, for their own protection, or for the capture of their prey, as the case may be. In the hydra the sac is ejected, and a central dart is projected into the body attacked. There must be a minute poison-sac in communication with the darts, as it is found that any soft-bodied victim, released from the clasp of the tentacles, is invariably dead, no matter how short the time of its imprisonment may have been. The effects of the cnidæ in the medusæ are very well known, and have gained for them their popular name of sea-nettles. Many an unlucky swimmer has found himself wrapped in the long thread-like filaments of these transparent, floating bells, and been almost maddened as he found himself inextricably inclosed in what seemed an invisible sheet of living fire. A tentacle of the hydroid, when carefully pressed between two glass slides, or in a compressorium, may be seen, under the microscope, to dart out thousands of these little barbed arrows.

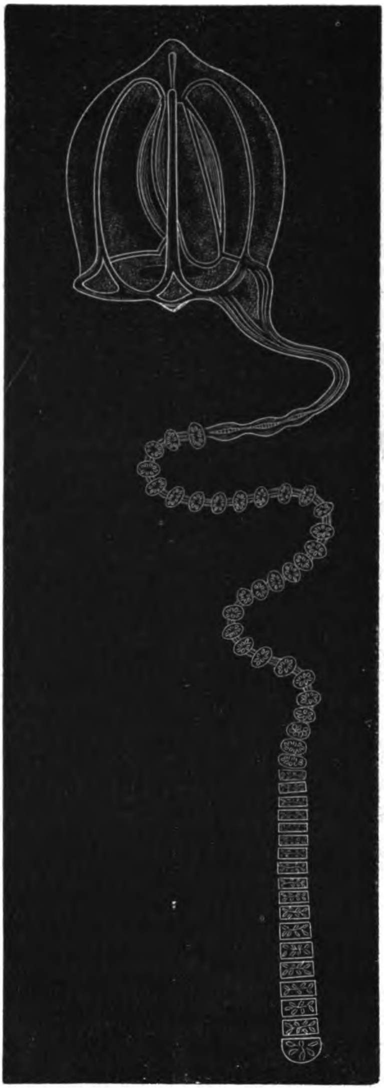

FIG. 11.—MEDUSA OF COROMORPHA NUTANS. (Magnified.)

Chronologically, the *Hydræ* (Fig. 12) come first in the group *Hydroidæ*, for they were first carefully studied and truly classified by Trembley. His observations, though made in the earlier half of the eighteenth century, were so accurate, and his delineations so correct, that he is still quoted in the latest works as authority. The hydra is found generally in fresh water, though some few species have been discovered, in this country, in that which is somewhat brackish. It loves still or slowly-running water, and attaches itself generally to the under-side of the leaves or to the stalks of aquatic plants. Its body is extremely contractile, and consists, like the oceanic hydroids, in its earliest stage of development, of a simple elongated sac, with an opening which answers the purpose of a mouth. Around the mouth are a series of hollow filaments which it can entirely withdraw, and it then looks like a minute tubercle. The tentacles are roughened by the clusters of thread-cells, or cnidæ, already described. The threads have been observed in some instances to be, when extended, as much as eight inches long, and are shot out, it is thought, by the propulsive power of a liquid injected into the central cavity. It grows erect, horizontal, or inverted, as the case may be, and lives only upon animal food. The little creatures are extremely voracious and not over-nice. Trembley observed two hydras attack, at the

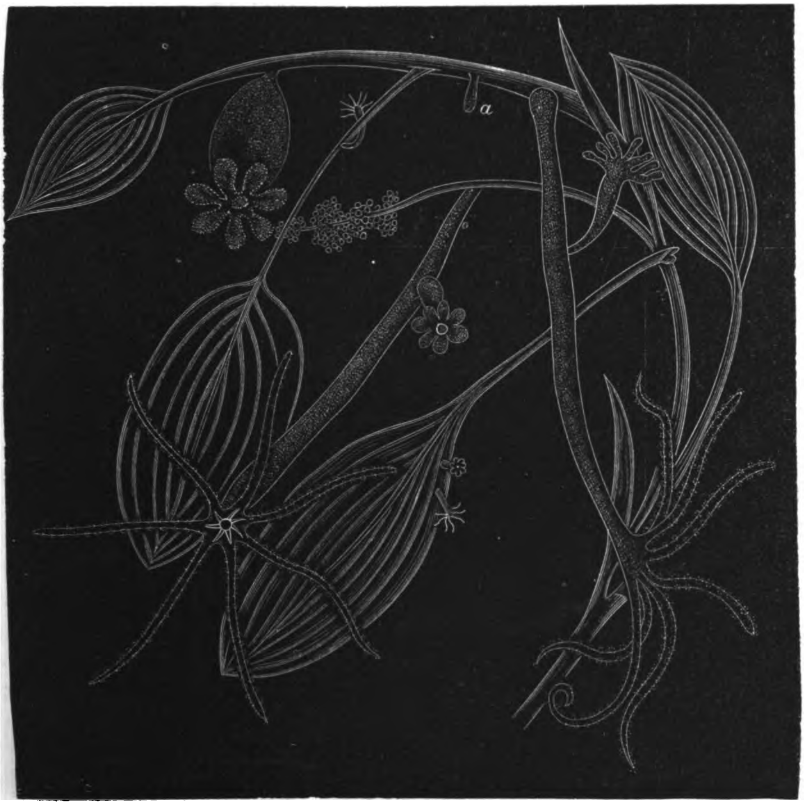

Fig. 12.—Hydra vulgaris. (Natural Size.)

same time, the opposite extremities of a worm. Each having swallowed its respective half of the worm, he watched to see the result. The worm would not yield to the force of circumstances; and break, and the problem looked a difficult one of solution. The larger hydra, however, proved itself superior to circumstances, it quietly swallowed worm, antagonist, and all; and, after having sucked out the worm, disgorged his dinnerless foe!

Trembley tried the experiment, already alluded to, of turning one inside out, and fastening it in that position. The domestic economy did not appear to be at all disturbed; the little creature eating with as much relish, and digesting with as much ease, to all appearance, as in its normal position. He inserted one hydra within the cavity of another, and fastened them with a bristle which was run through both. Returning after a short absence he found them strung, side by side, upon the bristle. He repeated the experiment and watched the manœuvres of the two. The hydra inside managed to work its way through the small aperture made in the side of its neighbor by the bristle, and soon occupied the position he had before observed, side by side with its companion on the bristle. He then turned one of them inside out, inserted it in that position, and fastened them securely together. Soon the pair, finding that there was no help for it, philosophically yielded, and united their fortunes; the inner one of the couple providing nourishment for them both. They seemed to live quite comfortably, on these very close terms of intimacy, for some time.

Hydras generate in summer by buds, which grow to maturity and are then sloughed off. These young buds often produce others before they separate from the parent stem, and they others again; so that there are sometimes twenty generations produced in a month's time. In autumn oviform gemmules are extruded, lie quiescent till spring, and are then developed. Any number of artificial sections may be made, and from each a perfect animal will be developed. Wherever a wound or cut has been made, buds sprout more quickly than from the sound tissue, and the hydras generated by artificial sections are more prolific than those generated in the ordinary way. The sprouting, as may be seen in the plate (Fig. 12), takes place from any portion of the body. The leaves, flowers, and stems, of this specimen of *Hydra vulgaris*, together form the hydrasoma. This specimen was selected more to illustrate the plant-like character of the organism than for its intrinsic beauty.

The geographical distribution of the *Hydroidæ* has not yet been determined; but, like other low forms of life, we find them spreading over vast areas of space, and extending back through uncounted ages of time. We have already spoken of their distribution in depth. A well-defined specimen was taken up in the deepest cast recorded by Wyville Thomson, in his "Depths of the Sea"—that made in the Bay of Biscay, and to a depth of nearly three miles. But, though their existence is proved at these enormous depths, they love best the rock-bound pools left by the retiring tide and the shallow water which fringes our islands and continents; and there they probably attain their greatest beauty and most perfect development.

Their distribution in time reaches back to the earliest dawnings of life upon our globe. The *Graptolites* of the Lower and Upper Silurian, the *Hydroid Medusæ* of the Jurassic, the *Hydractinea* of the Cretaceous, Miocene, and Pliocene, the *Serturella* of the Pleistocene, and the numberless forms of the present day, are the representatives of this family in geologic and historic time.

Like other humble forms of life, it shows a marvelous persistency. It has lived, almost unchanged, while great dynasties of higher organisms have one after the other risen, developed, and perished, or left only a few meagre representatives among the fauna of the present day. The fragility of their chitinous envelope and the perishable nature of their protoplasmic flesh would, of course, render it impossible that any full record of their existence should ever be found in the rocks of the primeval would, but the fragments which have, here and there, left their impress on the various geologic strata, show them to have been the contemporaries of the oldest forms of life which inhabited the Silurian seas, and to have quietly existed in the depths of those ancient waters over which the great fish and saurian dynasties lorded it through so many centuries.

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ORIGIN AND DEVELOPMENT OF ENGINEERING.[1]

BY SIR JOHN HAWKSHAW, F. R. S.

TO those on whom the British Association confers the honor of presiding over its meetings the choice of a subject presents some difficulty. The presidents of sections give accounts of what is new in their departments; and essays on science in general, though desirable in the earlier years of the Association, would be less appropriate to-day. Past presidents have discoursed on many subjects, on the mind and on things beyond the reach of mind, and I have arrived at the conclusion that humbler themes will not be out of place on this occasion. I propose to say something of a profession to which my life has been devoted—a theme which cannot stand as high in your estimation as in my own, but which I have chosen because I ought to understand it better than any other. I propose to say something on its origin, its work, and kindred topics.

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[1] *Times's* summary of Inaugural Address at the Bristol Meeting of the British Association.

Rapid as has been the growth of the art of the engineer during the last century, we must, if we would trace its origin, seek among the earliest evidences of civilization. When settled communities were few and isolated, opportunities for the interchange of knowledge were scanty or wanting. The slowly accumulated results of the experience of a community were lost on its downfall. Inventions were lost and found again. The art of casting bronze over iron was known to the Assyrians, though it has only lately been introduced into modern metallurgy; and patents were granted in 1609 for processes connected with the manufacture of glass, which had been practised centuries before. An inventor in the reign of Tiberius devised a method of producing flexible glass, but the manufactory of the artist was totally destroyed in order to prevent the manufacture of copper, silver, and gold, from becoming depreciated.

In the long discussion which was held as to the practicability of making the Suez Canal, an early objection was brought against it that there was a difference of thirty-two and one-half feet between the level of the Red Sea and that of the Mediterranean. Laplace declared that such could not be the case, for the mean level of the sea was the same on all parts of the globe. Centuries before the time of Laplace the same objection had been raised against a project for joining the waters of these two seas. According to the old Greek and Roman historians, it was a fear of flooding Egypt with the waters of the Red Sea that made Darius, and in later times again Ptolemy, hesitate to open the canal between Suez and the Nile. Yet this canal was made and was in use some centuries before the time of Darius. Strabo tells us that the same objection, that the adjoining seas were of different levels, was made by his engineers to Demetrius, who wished to cut a canal through the Isthmus of Corinth some two thousand years ago. But Strabo dismisses at once this idea of a difference of level, agreeing with Archimedes that the force of gravity spreads the sea equally over the earth.

When knowledge in its higher branches was confined to a few, those who possessed it were called upon to perform various services for the communities to which they belonged; and we find mathematicians, and astronomers, painters, sculptors, and priests, called upon to perform the duties which now pertain to the profession of the architect and the engineer. As soon as civilization had advanced so far as to admit of the accumulation of wealth and power, then kings and rulers sought to add to their glory while living by the erection of magnificent dwelling-places, and to provide for their aggrandizement after death by the construction of costly tombs and temples.

The earliest buildings of stone to which we can assign a date, with any approach to accuracy, are the pyramids of Ghizeh. The genius for dealing with large masses in building did not pass away with the pyramid-builders in Egypt, but their descendants continued to gain in mechanical knowledge. The Romans, though they did not commonly use such large stones in their own constructions, carried off the largest obelisks from Egypt and erected them at Rome, where more are now to be found than remain in Egypt.

It has sometimes been questioned whether the Egyptians had a knowledge of steel. It seems unreasonable to deny them this knowledge. Iron was known at the earliest times of which we have any record. It is often mentioned in the Bible, and in Homer; it is shown in the early paintings on the walls of the tombs at Thebes; it has been found in quantity in the ruined palaces of Assyria; and in the inscriptions of that country fetters are spoken of as having been made of iron, which is also so mentioned in connection with other metals as to lead to the supposition that it was regarded as a base and common metal. The quality of iron which is now made by the native races of Africa and India is that which is known as wrought-iron. Dr. Percy says the extraction of good malleable iron, directly from the ore, "requires a degree of skill very far inferior to that which is implied in the manufacture of bronze." The supply of iron in India as early as the fourth and fifth centuries seems to have been unlimited. In the temples of Orissa iron was used in large masses as beams or girders in roof-work in the thirteenth century, and India well repaid any advantage which she may have derived from the early civilized communities of the West if she were the first to supply them with iron and steel. If we look still farther to the East, China had probably knowledge of the use of metals as soon as India, and, moreover, had a boundless store of iron and coal. A great future is undoubtedly in store for that country; but can the race who now dwell there develop its resources, or must they await the aid of an Aryan race? The art of extracting metals from the ore was practised at a very early date in this country. The Romans worked iron extensively in the Weald of Kent, as we assume from the large heaps of slag containing Roman coins which still remain there. Coal, which was used for ordinary purposes in England as early as the ninth century, does not appear to have been largely used for iron-smelting until the eighteenth century, though a patent was granted for smelting iron with coal in the year 1611. The use of charcoal for that purpose was not given up until the beginning of this century, since which period an enormous increase in the mining and metallurgical industries has taken place; the quantity of coal raised in the United Kingdom in 1873 having amounted to 127,000,000 tons, and the quantity of pig-iron to upward of 6,500,000 tons.

The early building energy of the world was chiefly spent on the erection of tombs, temples, and palaces. While in Egypt, as we have seen, the art of building in stone had 5,000 years ago reached the greatest perfection, so in Mesopotamia the art of building with brick, the only available material in that country, was in an equally advanced state some ten centuries later. The practice of building great pyramidal temples seems to have passed eastward to India and Burmah, where it appears in buildings of a later date, in Buddhist topes and pagodas; marvels of skill in masonry, and far surpassing the old brick mounds of Chaldea in richness of design and in workmanship. Egypt was probably far better irrigated in the days of the Pharaohs than it is now; and Lake Mœris, of which the remains have been explored by M. Linant, was a reservoir made by one of the Pharaohs, and supplied by the flood-waters of the Nile. It was 150 square miles in extent, and was retained by a bank or dam 60 yards wide and 10 high, which can be traced for a distance of 13 miles. This reservoir was capable of irrigating 1,200 square miles of country. No work of this class has been undertaken on so vast a scale since, even in these days of great works. The springs of knowledge which had flowed so long in Babylonia and Assyria were dried up at an early period; but Egypt remained the fountain-head whence knowledge flowed to Greece and Rome. The early constructive works of Greece, till about the seventh century B. C., form a strong contrast to those of its more prosperous days. Commonly called Pelasgian, they are more remarkable as engineering works than admirable as those which followed them were for architectural beauty. Walls of huge unshapely stones — admirably fitted together, however — tunnels, and bridges characterize this period. In Greece, during the few and glorious centuries which followed, the one aim in all construction was to please the eye, to gratify the sense of beauty; and in no age was that aim more thoroughly and satisfactorily attained.

In these days, when sanitary questions attract each year more attention, we may call to mind that twenty-three centuries ago the city of Agrigentum possessed a system of sewers, which on account of their large size was thought worthy of mention by Diodorus. This is not, however, the first record of towns being drained. The well-known Cloaca Maxima, which formed part of the drainage system of Rome, was built some two centuries earlier, and great vaulted drains passed beneath the palace-mounds of unburnt brick at Nimroud and Babylon, and possibly we owe the preservation of many of the interesting remains found in the brick-mounds of Chaldea to the very elaborate system of pipe drainage discovered in them and described by Loftus. While Pelasgian art was being superseded in Greece, the city of Rome was founded, in the eighth century before our era; and Etruscan art in Italy, like the Pelasgian art in Greece, was slowly merged in that of an Aryan race.

It would be impossible for me to do justice to even a small part of the engineering works which remain to this day as monuments of the skill, the energy, and ability, of the great Roman people. War, with all its attendant evils, has often indirectly benefited mankind. In the sieges which took place during the wars of Greece and Rome, the inventive power of man was taxed to the utmost to provide machines for attack and defense. The ablest mathematicians and philosophers were pressed into the service, and helped to turn the scale in favor of their employers. The world has to regret the loss of more than one who, like Archimedes, fell slain by the soldiery while applying the best scientific knowledge of the day to devising means of defense during the siege. The necessity for roads and bridges for military purposes has led to their being made where the stimulus from other causes was wanting; and means of communication and the interchange of commodities, so essential to the prosperity of any community, have thus been provided. Such was the case under the Roman Empire. So, too, in later times, the ambition of Napoleon covered France and the countries subject to her with an admirable system of military roads. So, again, in this country, it was the rebellion of 1745, and the want felt of roads for military purposes, which first led to the construction of a system of roads in it unequaled since the time of the Roman occupation. And lastly, in India, in Germany, and in Russia, more than one example could be pointed out where industry will be benefited by railways which have originated in military precautions rather than in commercial requirements.

But to return to Rome. Roads followed the tracks of her legions into the most distant provinces of the empire. Three hundred and seventy-two great roads are enumerated, together more than 48,000 miles in length, according to the itinerary of Antoninus. The water-supply of Rome during the first century of our era would suffice for a population of 7,000,000, supplied at the rate at which the present population of London is supplied. This water was conveyed to Rome by nine aqueducts; and in later years the supply was increased by the construction of five more aqueducts. Three of the old aqueducts have sufficed to supply the wants of the city in modern times. These aqueducts of Rome are to be numbered among her grandest engineering works. Time will not admit of my saying any thing about her harbor works and bridges, her basilicas and baths, and numerous other works in Europe, in Asia, and in Africa.

In the fourth and succeeding centuries the barbarian hordes of Western Asia, people who felt no want of roads and bridges, swept over Europe to plunder and destroy. With the seventh century began the rise of the Mohammedan power, and a partial return to conditions apparently more favorable to the progress of industrial art, when wide-spread lands were again united under the sway of powerful rulers. Still, few useful works remain to mark the supremacy of the Mohammedan power at all comparable to those of the age which preceded its rise.

A great building-age began in Europe in the tenth century, and lasted through the thirteenth. While the building of cathedrals progressed on all sides in Europe, works of a utilitarian character, which concern the engineer, did not receive such encouragement, excepting perhaps in Italy. In India, under the Moguls, irrigation works, for which they had a natural aptitude, were carried on during these centuries with vigor, and more than one emperor is noted for the numerous great works of this nature which he carried out.

It is frequently easier to lead water where it is wanted than to check its irruption into places where its presence is an evil, often a disaster. For centuries the existence of a large part of Holland has been dependent on the skill of man. How soon he began in that country to contest with the sea the possession of the land we do not know, but early in the twelfth century dikes were constructed to keep back the ocean. To the practical knowledge acquired by the Dutch, whose method of carrying out hydraulic works is original and of native growth, much of the knowledge of the present day in embanking, and draining, and canal-making, is due. While the Dutch were acquiring practical knowledge in dealing with water, and we in Britain, among others, were benefiting by their experience, the disastrous results which ensued from the inundations caused by the Italian rivers of the Alps gave a new importance to the science of hydraulics. Some of the greatest philosophers of the seventeenth century—among them Torricelli, a pupil of Galileo—were called upon to advise and to superintend engineering works; nor did they confine themselves to the construction of preventive works, but thoroughly investigated the condition pertaining to fluids at rest or in motion, and gave to the world a valuable series of works on hydraulics and hydraulic engineering, which form the basis of our knowledge of these subjects at the present day.

The impulse given to road-making in the early part of the last century soon extended to canals, and means for facilitating locomotion and transport generally. Tramways were used in connection with mines at least as early as the middle of the seventeenth century, but the rails were, in those days, of wood. The first iron rails are said to have been laid in this country as early as 1738, after which time their use was gradually extended, until it became general in mining districts. By the beginning of this century the great ports of England were connected by a system of canals; and new harbor-works became necessary, and were provided to accommodate the increase of commerce and trade, which improved means of internal transport had rendered possible. But it was not until the steam-engine, improved and almost created by the illustrious Watt, became such a potent instrument, that engineering works to the extent they have since been carried out became possible or necessary. But, while Watt had gained a world-wide, well-earned fame, the names of those men who have provided the machines to utilize the energies of the steam-engine are too often forgotten. Of their inventions the majority of mankind know little. They worked silently at home, in the mill, or in the factory, observed by few. Indeed, in most cases these silent workers had no wish to expose their work to public gaze. How long in the silent night the inventors of these machines sat and pondered; how often they had to cast aside some long-sought mechanical movement and seek another and better arrangement of parts, none but themselves could ever know. They were unseen workers, who succeeded by rare genius, long patience, and indomitable perseverance.

More ingenuity and creative mechanical genius is perhaps displayed in machines used for the manufacture of textile fabrics than by those used in any other industry. It was not until late in historical times that the manufacture of such fabrics became established on a large scale in Europe. Linen was worn by the old Egyptians, and some of their linen mummy-cloths surpass in fineness any linen fabrics made in later days. The Babylonians wore linen also and wool, and obtained a wide-spread fame for skill in workmanship and beauty in design. In this country wool long formed the staple for clothing. Silk was the first rival, but its costliness placed it beyond the reach of the many. To introduce a new material or improved machine into this or other countries a century or more ago was no light undertaking. Inventors and would-be benefactors alike ran the risk of loss of life. Loud was the outcry made in the early part of the eighteenth century against the introduction of Indian cottons and Dutch calicoes. Until 1738, in which year the improvements in spinning-machinery were begun, each thread of worsted or cotton-wool had been spun between the fingers, in this and all other countries. Wyatt, in 1738, invented spinning by rollers instead of fingers, and his invention was further improved by Arkwright. In 1770 Hargreaves invented the spinning-jenny, and Crompton the mule in 1775, a machine which combined the advantages of the frames of both Hargreaves and Arkwright. In less than a century after the first invention by Wyatt, double mules were working in Manchester with over 2,000 spindles. Improvements in machines for weaving were begun at an earlier date. In 1579 a ribbon-loom is said to have been invented at Dantzic, by which from four to six pieces could be woven at one time, but the machine was destroyed and the inventor lost his life. In 1800 Jacquard's most ingenious invention was brought into use, which, by a simple mechanical operation, determines the movements of the threads which form the pattern in weaving. But the greatest improvement in the art of weaving was wrought by Cartwright's discovery of the power-loom, which led eventually to the substitution of steam for manual labor, and enabled a boy with a steam-loom to do fifteen times the work of a man with a hand-loom. For complex ingenuity few machines will compare with those used in the manufacture of lace and bobbin net. Hammond, in 1768, attempted to adapt the stocking-frame to this manufacture, which had hitherto been conducted by hand. It remained for John Heathcoat to complete the adaptation in 1809, and to revolutionize this branch of industry, reducing the cost of its produce to one-fortieth of what the cost had been before Heathcoat's improvements were effected. Time would fail me if I were to attempt to enumerate one tithe of these rare combinations of mechanical skill; and, indeed, no one will ever appreciate the labor and supreme mental effort required for their construction who has not himself seen them and their wondrous achievements.

Steamboats, the electric telegraph, and railways, are more within the cognizance of the world at large, and the progress that has been made in them in little more than one generation is better known and appreciated. It is not more than forty years since one of our scientific men, and an able one too, declared at a meeting of this Association that no steamboat would ever cross the Atlantic; founding his statement on the impracticability, in his view, of a steamboat carrying sufficient coal, profitably, I presume, for the voyage. Like most important inventions, that of the steamboat was a long time in assuming a form capable of being profitably utilized, and, even when it had assumed such a form, the objections of commercial and scientific men had still to be overcome. The increase in the number of steamboats since the time when the Sirius first crossed the Atlantic has been very great. Whereas in 1814 the United Kingdom only possessed two steam-vessels, of together 456 tons burden, in 1872 there were on the register of the United Kingdom 3,662 steam-vessels, of which the registered tonnage amounted to over a million and a half of tons, or to nearly half the whole steam tonnage of the world, which did not at that time greatly exceed three million tons. As the number of steamboats has largely increased, so also gradually had their size increased until it culminated in the hands of Brunel in the Great Eastern. A triumph of engineering skill in ship-building, the Great Eastern has not been commercially so successful. In this, as in many other engineering problems, the question is not how large a thing can be made, but how large, having regard to other circumstances, it is proper at the time to make it.

A distinguished member of this Association, Mr. Froude, has now for some years devoted himself to investigations carried on with a view to ascertain the form of vessel which will offer the least resistance to the water through which it must pass. So many of us in these days are called upon to make journeys by sea as well as by land that we can well appreciate the value of Mr. Froude's labors, so far as they tend to curtail the time which we must spend on our ocean-journeys; and we should all feel grateful to him if from another branch of his investigations, which relates to the rolling of ships, it would result that the movement in passenger-vessels could be reduced.

There is no more remarkable instance of the rapid utilization of what was at first regarded as a mere scientific idea than the adoption and extension of the electric telegraph. Those who read Odier's letter written in 1773, in which he made known his idea of a telegraph which would enable the inhabitants of Europe to converse with the Great Mogul little thought that in less than a century a conversation between persons at points so far distant would be possible. Still less did those, who saw in the following year messages sent from one room to another by Lesage in the presence of Frederick of Prussia, realize that they had before them the germ of one of the most extraordinary inventions among the many that will render this century famous. I should weary you were I to follow the slow steps by which the electric telegraph of to-day was brought to its present state of efficiency; but yet within how short a period of time has all the wonderful progress been achieved! How incredulous the world a few years ago would have been if then told of the marvels which in so short a space of time were to be accomplished by its agency! It is not long ago—1823—that Mr. (now Sir Francis) Ronald, one of the early pioneers in this field of science, published a description of an electric telegraph. He communicated his views to Lord Melville, and that nobleman was obliging enough to reply that the subject should be inquired into; but before the nature of Sir Francis Ronald's suggestions could be known, except to a few, that gentleman received a reply from Mr. Barrow that "telegraphs of any kind were then wholly unnecessary, and that no other than the one then in use would be adopted;" the one then in use being the old semaphore, which, crowning the tops of hills between London and Portsmouth, seemed perfection to the Admiralty of that day. The telegraphic system of the world comprises almost a complete girdle round the earth; and it is probable that the missing link will be supplied by a cable between San Francisco, in California, and Yokohama, in Japan. How resolute and courageous those who engaged in submarine telegraphy have been will appear from the fact that, though we have now 50,000 miles of cable in use, to get at this result nearly 70,000 miles were constructed and laid.

Of railways the progress has been enormous; but I do not know that in a scientific point of view a railway is so marvelous in its character as the electric telegraph. The results, however, of the construction and use of railways are more extensive and wide spread, and their utility and convenience brought home to a larger portion of mankind. The British Association is peripatetic, and without railways its meetings, if held at all, would, I fear, be greatly reduced in numbers. Moreover, you have all an interest in them; you all demand to be carried safely, and you insist on being carried fast. I shall not enter on a history of the struggles which preceded the opening of the first railway. They were brought to a successful issue by the determination of a few able and far-seeing men. The names of Thomas Gray and Joseph Sandars, of William James and Edward Pease, should always be remembered in connection with the early history of railways, for it was they who first made the nation familiar with the idea. There is no fear that the name of Stephenson will be forgotten, whose practical genius made the realization of the idea possible. Railways add enormously to the national wealth. More than twenty-five years ago it was proved, to the satisfaction of a committee of the House of Commons, that the Lancashire & Yorkshire Railway effected a saving to the public using the railway of more than the whole amount of the dividend which was received by the proprietors. These calculations were based solely on the amount of traffic carried by the railway and on the difference between the railway rate of charge and the charges by the modes of conveyance anterior to railways. No credit whatever was taken for the saving of time, though in England preëminently time is money. Considering that railway charges on many items have been considerably reduced since that day, it may be safely assumed that the railways in the British Islands now produce, or rather save to the nation, a much larger sum annually than the gross amount of all the dividends payable to the proprietors, without at all taking into account the benefit arising from the saving in time. The benefits under that head defy calculation, and cannot with any accuracy be put into money; but it would not be at all over-estimating this question to say that in time and money the nation gains at least what is equivalent to ten per cent. on all the capital expended on railways. It follows that, whenever a railway can be made at a cost to yield the ordinary interest of money, it is in the national interest that it should be made. Further, that, though its cost might be such as to leave a smaller dividend than that to its proprietors, the loss of wealth to so small a section of the community will be more than supplemented by the national gain, and therefore there may be cases where a government may wisely contribute in some form to undertakings which, without such aid, would fail to obtain the necessary support. And so some countries—Russia, for instance—to which improved means of transport are of vital importance, have wisely, in my opinion, caused lines to be made which, having regard to their own expenditure and receipts, would be unprofitable works, but in a national point of view are or speedily will be highly advantageous.

A question more important probably in the eyes of many—safety of railway-traveling—may not be inappropriate. At all events, it is well that the elements on which it depends should be clearly understood. It will be thought that longer experience in the management of railways should go to insure greater safety, but there are other elements of the question which go to counteract this in some degree. The safety of railway-traveling depends on the perfection of the machine in all its parts, including the whole railway, with its movable plant, in that term; it depends also on the nature and quantity of traffic; and, lastly, on human care and attention. With regard to what is human, it may be said that so many of these accidents as arise from the fallibility of men will never be eliminated until the race be improved. The liability to accident will also increase with the speed, and might be reduced by slackening that speed. It increases with the extent and variety of the traffic on the same line. The public, I fear, will rather run the risk than consent to be carried at a slower rate. The increase in extent and variety of traffic is not likely to receive any diminution; on the contrary, it is certain to augment. I should be sorry to say that human care may not do something, and I am not among those who object to appeals through the press and otherwise to railway companies, though sometimes perhaps they may appear in an unreasonable form. I see no harm in men being urged in every way to do their utmost in a matter so vital to many. It is practicable, by certain corrections of the official returns, to make some sort of comparison between the accidents in the earlier days of our own railways and the accidents occurring at a later date. I have endeavored to make these corrections, and I believe the results arrived at may be taken as fairly accurate. From the figures it appears that the passenger mileage has doubled between 1861 and 1873; and at the rate of increase between 1870 and 1873 it would become double what it was in 1873 in twelve years from that time—namely, in 1885. The number of passengers has doubled between 1864 and 1873, and at the rate of increase between 1870 and 1873 it would become double what it was in 1873 in eleven and a half years, or in 1885. Supposing no improvement had been effected in the working of railway-traffic, the increase of accidents should have borne some proportion to the passenger mileage, multiplied by the proportion between the train mileage and the length of line open, as the number of trains passing over the same line of rails would tend to multiply accidents in an increasing proportion, especially where the trains run at different speeds. The number of accidents varies considerably from year to year, but, taking two averages of ten years each, it appears that the proportion of deaths of passengers from causes beyond their control to passenger miles traveled in the ten years ending December 31, 1873, was only two-thirds of the same proportion in the ten years ending December 31, 1861. The limit of improvements will probably be reached before long, and the increase of accidents will depend on the increase of traffic, together with the increased frequency of trains. Up to the present time the improvements appear to have kept pace with the increase of traffic and of speed, as the slight increase in the proportion of railway accidents to passenger miles is probably chiefly due to a larger number of trifling bruises being reported now than formerly. I believe it was a former president of the Board of Trade who said to an alarmed deputation, who waited upon him on the subject of railway traveling, that he thought he was safer in a railway-carriage than anywhere else. If he gave any such opinion, he was not far wrong, as is sufficiently evident when it can be said that there is only one passenger injured in every four million miles traveled, or that, on an average, a person may travel 100,000 miles each year for forty years, and the chances be slightly in his favor of his not receiving the slightest injury.

A pressing subject of the present time is the economy of fuel. Members of the British Association have not neglected this momentous question. Many cases of waste arise from the existence of old and obsolete machines, of bad forms of furnaces, of wasteful grates, existing in most dwelling-houses; and these are not to be remedied at once, for not every one can afford, however desirable it might be, to cast away the old and adopt the new. In looking uneasily to the future supply and cost of fuel, it is, however, something to know what may be done even with the application of our present knowledge; and, could we apply it universally to-day, all that is necessary for trade and comfort could probably be as well provided for by one-half the present consumption of fuel; and it behooves those who are beginning to build new mills, new furnaces, new steamboats, or new houses, to act as though the price of coal which obtained two years ago had been the normal and not the abnormal price.

There was in early years a battle of the gauges, and there is now a contest about guns; but your time will not permit me to say much on their manufacture. Here, again, the progress made in a few years has been enormous, and in contributing to it, two men—Sir William Armstrong and Sir Joseph Whitworth, both civil engineers—in this country, at all events, deservedly stand foremost. Docks and harbors I have no time to mention, for it is time this long and, I fear, tedious address should close.

"Whence and whither" is the aphorism which leads us away from present and plainer objects to those which are more distant and obscure; whether we look backward or forward our vision is speedily arrested by an impenetrable veil. On the subject I have chosen you will probably think I have traveled backward far enough. I have dealt to some extent with the present. The retrospect, however, may be useful to show what great works were done in former ages. Some things have been better done than in those earlier times, but not all. In what we choose to call the ideal we do not surpass the ancients. Poets and painters and sculptors were as great in former times as now; so, probably, were the mathematicians. In what depends on the accumulation of experience we ought to excel our forerunners. Engineering depends largely on experience; nevertheless, in future times whenever difficulties shall arise, or works have to be accomplished for which there is no precedent, he who has to perform the duty may step forth from any of the walks of life, as engineers have not unfrequently hitherto done. The marvelous progress of the last two generations should make every one cautious of predicting the future. Of engineering works it may be said that their practicability or impracticability is often determined by other elements than the inherent difficulty in the works themselves. Greater works than any yet achieved remain to be accomplished—not, perhaps, yet awhile. Society may not yet require them; the world could not at present afford to pay for them. The progress of engineering works, if we consider it, and the expenditure upon them, has already in our time been prodigious. One hundred and sixty thousand miles of railway alone, put into figures at £20,000 a mile, amounts to £3,200,000,000 sterling; add 400,000 miles of telegraph at £100 a mile, and £100,000,000 more for sea-canals, docks, harbors, water and sanitary works constructed in the same period, and we get the enormous sum of £3,340,000,000 sterling expended in one generation and a half on what may undoubtedly be called useful works. The wealth of nations may be impaired by expenditure on luxuries and war; it cannot be diminished by expenditure on works like these.

As to the future, we know we cannot create a force; we can, and no doubt shall, greatly improve the application of those with which we are acquainted. What we called inventions can do no more than this, yet how much every day is being done by new machines and instruments! The telescope extended our vision to distant worlds. The spectroscope has far outstripped that instrument, by extending our powers of analysis to regions as remote. Postal deliveries were and are great and able organizations, but what are they to the telegraph? Need we try to extend our vision into futurity farther? Our present knowledge, compared with what is unknown even in physics, is infinitesimal. We may never discover a new force—yet, who can tell?

INSECTIVOROUS PLANTS.

BY E. R. LELAND.

MOST amateur botanists have in the course of their walks come upon the peculiar leaves of the common sundew (*Drosera rotundifolia*), with the clear drops which the leaves bear glistening in the morning sun, and, on referring to their manuals, have noted the relationship which it bears to Venus's fly-trap (*Dionæa muscipula*), whose famous irritability is always a matter for mention.

In collecting the showy side-saddle-flower (*Sarracenia purpurea*), they have, of course, observed that its curious, trumpet-shaped leaves are usually half-filled with water and drowned insects.

In fishing from the stagnant pools, the inconspicuous, yellow blossoms, and rootless capillary leaves of the bladderwort (*Utricularia vulgaris*), they have doubtless noticed how they swarmed with insects and small crustaceans; and have accepted, with that unhesitating faith which our whole system of education begets and fosters, the statement that the little bladders are filled with air, and that their function is to float the plant at the time of flowering.

Possibly they may have noticed that the sticky leaves of the butterwort (*Pinguicula vulgaris*) are sometimes strongly incurved.

If, observing these matters, they have given them but a passing thought; have failed to see the relation, or apprehend the motives of the phenomena; and are surprised some day by learning that they point to one of the most wonderful discoveries of modern biology—they need reproach themselves with no exceptional heedlessness or obtuseness, for they have the illustrious company of most of the famous botanists from Linnæus down to those of the present generation.

Some attention has recently been called to the carnivorous habits of what Dr. Hooker calls "our brother-organisms—plants," by the appearance in different scientific periodicals of some brief note, or paper, by occasional observers; and more generally by Prof. Gray's papers which appeared in the *Nation*, April, 1874, pp. 216, 232, in which he announced some of the facts that had been communicated by Mr. Darwin and others. Some of these statements must, it should be said, be modified in the light of later observations.

It has turned out, as so often it does, that some of the more obvious observations and conclusions were made and drawn long ago, and recorded only to be overlooked and forgotten. The subject has a history running back a century or more. It is of more than common interest, and has been well told by Dr. Joseph Hooker, in his address to the department of Zoölogy and Botany, British Association, Belfast, August, 1874. Much condensed, it is as follows:

Dionæa.—About 1768, Ellis, a well-known English naturalist, sent to Linnæus a drawing of a plant, to which he gave the poetical name of *Dionæa.* "The plant," wrote Ellis, "shows that Nature may have some views toward its nourishment in forming the upper joint of its leaf like a machine to catch food; upon the middle of this lies the bait for the unhappy insect that becomes its prey. Many minute red glands that cover its surface tempt the animal to taste them; and, the instant these tender parts are irritated by its feet, the two lobes rise up, grasp it fast, lock the rows of spines together, and squeeze it to death. And further, lest the strong efforts for life in the creature, just taken, should serve to disengage it, three small spines are fixed near the middle of each lobe, among the glands, that effectually put an end to its struggles. Nor do the lobes ever open again while the dead animal continues there. It is nevertheless certain that the plant cannot distinguish an animal from a vegetable or mineral substance; for, if we introduce a straw or pin between the lobes, it will grasp it fully as fast as if it were an insect."

This account, substantially correct, but erroneous in some particulars, led Linnæus to declare that, though he had seen and examined no small number of plants, he had never met with so wonderful a phenomenon. He was, however, too sagacious to accept Ellis's account of the *coup-de-grâce* which the insects received from the three stiff hairs in the centre of each lobe of the leaf. He was also unable to bring himself to believe that Nature intended the plant "to receive some nourishment from the animals it seizes," and he accordingly declared that, as soon as the insects ceased to struggle, the leaf opened and let them go. He only saw in these wonderful actions an extreme case of sensitiveness in the leaves; and he consequently regarded the capture of the disturbing insects as merely accidental, and of no importance to the plant.

Linnæus's authority caused his statements to be faithfully copied from book to book.

Sixty years after Linnæus wrote, an able botanist, the Rev. Dr. M. A. Curtis (who died in 1872), lived at Wilmington, North Carolina, the headquarters of this very local plant. In 1834 he published an account of it in the *Boston Journal of Natural History*, which is a model of accurate scientific observation. He said: "Each half of the leaf is a little concave on the inner side, where there are placed three delicate, hair-like organs, in such order that an insect can hardly traverse it without interfering with one of them, when the two sides suddenly collapse, and inclose the prey, with a force surpassing an insect's efforts to escape. The fringes of hairs on the opposite sides of a leaf interlace like the fingers of two hands clasped together. The sensitiveness resides only in these hair-like processes on the inside, as the leaf may be touched or pressed in another part without sensible effects. The little prisoner is not crushed and suddenly destroyed, for I have often liberated captive flies and spiders which sped away as fast as fear or joy could carry them. At other times, I have found them enveloped in a fluid of mucilaginous consistence which seems to act as a solvent, the insects being more or less consumed in it. This circumstance has suggested the possibility of their being made subservient to the nourishment of the plant through an apparatus of absorbent vessels in the leaves."

To Ellis belongs the credit of divining the purpose of the capture of insects by the *Dionœa*. But Curtis made out the details of mechanism by ascertaining the seat of the sensitiveness of the leaves; and he also pointed out that the secretion was not a lure exuded before the capture, but a true digestive fluid poured out like our own gastric juice after the ingestion of food. (Prof. Gray quotes Dr. Curtis's observations on the *Dionœa* in his "Genera of the Plants of the United States," vol. i., p. 196, 1849, without comment; and his plate of the plant does not show any of the important sensitive spines.)

The investigation of this curious question again rested until 1868, when it was taken up by Mr. Canby, who was then staying in the *Dionœa* district. He found that the leaf had the power of dissolving animal matter, and that small pieces of beef that were fed to it were completely dissolved and absorbed; the leaf opening again with a dry surface and ready for another meal, though with an appetite somewhat jaded. It not only could be surfeited, but it suffered from indigestion; and a meal of cheese disagreed with the leaves so seriously as finally to kill them.

Finally, Dr. Burdon-Sanderson has made an important contribution to this investigation, by demonstrating the correspondence between the electrical phenomena which accompany muscular action and those which are associated with the closing of the Dionæa-leaf. He has shown that, not alone in the electrical but in structural changes which ensue, the resemblance is complete between the contraction of muscle and that of the leaf; and, the further the inquiry is pursued, the more striking does the resemblance appear.

Drosera.—Unlike the preceding genus, which is confined to a single district, the sundews are widely distributed. The fact that they are closely related to the *Dionœa* was little known when the curious habits, which are now attracting so much attention, were first discovered.

Mr. Gardom, a Derbyshire botanist, gives an account of what his friend Mr. Whateley, an eminent London surgeon, made out in 1780: "On inspecting some of the contracted leaves we observed a small insect very closely imprisoned therein, which occasioned some astonishment as to how it happened to get into so confined a situation. Afterward, on Mr. Whateley's centrically pressing with a pin other leaves yet in their natural and unexpanded form, we observed a remarkably sudden and elastic spring of the leaves, so as to become inverted upward, and, as it were, encircling the pin, which evidently showed the method by which the fly came into its embarrassing situation."

This account, which is erroneous in representing the movement of the hairs as much more rapid than it really is, must have been written from memory.

In July of the preceding year (though the account was not published till two years afterward), Roth, in Germany, had remarked, in *Drosera rotundifolia* and *longifolia*, that "many leaves were folded together from the point toward the base, and that all the hairs were bent like a bow." Upon opening these leaves, he says: "I found in each a dead insect; hence I imagined that this plant, which has some resemblance to the *Dionœa muscipula*, might also have a similar moving power. . . . With a pair of pliers I placed an ant upon the middle of the leaf of *D. rotundifolia*. The ant endeavored to escape, but was held fast by the clammy juice at the points of the hairs, which was drawn out by its feet into fine threads. In some minutes, the short hairs on the disk of the leaf began to bend, and in some hours the end of the leaf was so bent inward as to touch the base. The ant died in fifteen minutes, which was before all the hairs had bent themselves."

These facts, established nearly a century ago, by the testimony of independent observers, have up to the present time been almost ignored.

More recently, however, they have been repeatedly verified: in Germany, by Nilschke, in 1860; in this country by L. A. Millington, a correspondent of the *American Naturalist*, April, 1868; by Mrs. Treat, of New Jersey, *American Journal of Science*, November, 1871, and *American Naturalist*, December, 1873; by Mr. A. W. Bennett, at the meeting of the British Association for the Advancement of Science, 1873.

It is noticeable that all of these observers unite in reporting one erroneous conclusion, namely, that the movements do not result when inorganic substances are placed upon the leaves. Darwin's experiments show that although the effect is not so great and the substances are not so long detained, yet such bodies as bits of cinder do possess the power of irritation.

Mrs. Treat also reported that, when a living fly was pinned at a distance of half an inch from the leaves of the *D. filiformis*, the leaves bent toward it and reached it in an hour and twenty minutes. Mr. Darwin was not only unable to obtain any similar results, but, to admit that this motion was any thing other than an accident, would compel him to adopt some other theory than the one he now holds to account for the transmission of the impulse to motion.

Reference may here be made to a remarkable statement in a note of M. Ziegler to the Paris Academy of Sciences, in 1872. He says: "In studying these remarkable plants, I noticed that all the albuminoid animal substances, if held for a moment between the fingers, acquired the property of making the hairs of the *Drosera* contract. I also observed that such substances, when they had not been in contact with a living animal, had no visible action on the hairs. This shows that the simple contact of the fingers communicates to inert animal substances a property which they did not possess before." Repeated experiments, in which every precaution was taken by Mr. Darwin, seem effectually to negative this extraordinary belief of M. Ziegler.

This, then, is a brief review of the subject up to the recent publication of Mr. Darwin's book upon it. It has for some time been known, to all who have followed the question, that he was engaged in researches that would one day be published, and they have been waiting for them with eager interest. With characteristic patience and caution, it is only after fifteen years of careful investigation that he puts forth the results of the long series of observations. As one reads the book, the most vivid impression made is by the wonderful amount of painstaking labor that the record of the experiments shows. Like the artist of Kouroo, he seems to have said to himself: "Time is an ingredient that enters into no perfect work; and my work shall be perfect in all respects, though I should do nothing else in my life." And, lo!

while the task which he set to himself was to answer the question, "Why the *Drosera* caught such numbers of insects," the result has been the most valuable contribution to botanical literature which this age has seen. Competent critics pronounce it more important than his works on the "Fertilization of Orchids," and the "Movements and Habits of Climbing Plants;" and in scientific research there is, for Mr. Darwin, no higher standard of comparison than to compare him with himself.

The greater part of the book is given to the record of observations on the phenomena shown by *Drosera rotundifolia.* This well-known plant bears from two or three to five or six leaves, generally extended more or less horizontally, but sometimes extending vertically upward. The shape and general appearance are shown, as seen from above, in Fig. 1:

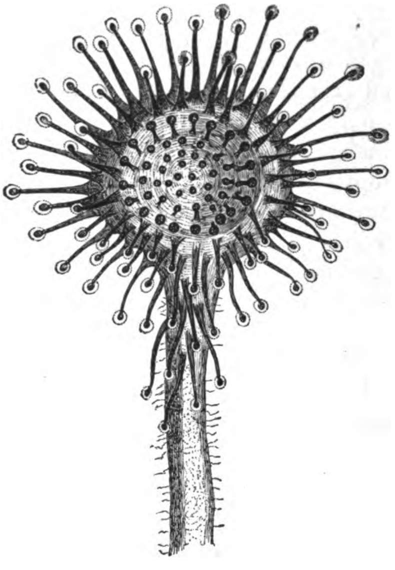

FIG. 1.—DROSERA ROTUNDIFOLIA.—Leaf viewed from above; enlarged four times.

The leaves are commonly a little broader than long; the whole upper surface being covered with gland-bearing filaments, or tentacles, as Mr. Darwin calls them, from their manner of acting.

A tentacle consists of a thin, straight, hair-like pedicel, carrying a gland on the summit. Each gland is surrounded by a large drop of extremely viscid secretion; they average about two hundred on each leaf, and as they glitter in the morning sun have given to the plant its poetical name. The tentacles on the central part of the leaf are short and stand upright, and their pedicels are green. Toward the margin they become longer and longer and more inclined outward, with their pedicels of a purple color. Those on the extreme margin project in the same plane with the leaf, or more commonly (*see* Fig. 2) are considerably reflexed.

If a small object be placed on the glands in the centre of the leaf, a motor impulse is transmitted to the marginal tentacles. The nearer ones are first affected, and then those farther off, until at last all are slowly but unerringly inflected, and close over the object. This takes place in from one to five or more hours; the difference in time depending on several circumstances, as the size of the object and its nature; on the vigor and age of the leaf; whether it has lately been in action; and the temperature.

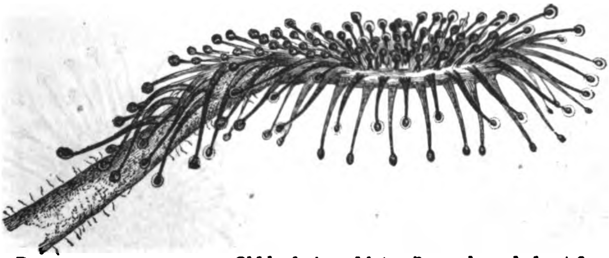

FIG. 2.—DROSERA ROTUNDIFOLIA.—Old leaf viewed laterally; enlarged about five times.

The tentacles in the centre do not become inflected when directly excited, though they are capable of inflection if excited by a motor impulse from other glands; but through and from them the motor impulse spreads gradually on all sides. Such is not the case with the marginal tentacles. If a bit of meat be placed on one of these it quickly transmits an impulse to its own bending portion, but never to those adjoining (*see* Fig. 5), for these are never affected until the meat has been carried to the central glands, which then radiate their conjoined impulse on all sides.

The sensitiveness of the leaves is located in the glands together with the immediately underlying cells of the tentacles. Though it is necessary that the glands should be touched, it is wonderful how slight a pressure will suffice. A bit of human hair $\frac{1}{50}$ of an inch in length and weighing only $\frac{1}{78740}$ of a grain will induce motion, transmit a motor impulse through the whole length of a marginal tentacle, and cause it to sweep through an angle of 180° or more. This minute morsel, it must be borne in mind, rests upon and is supported by the dense, viscid fluid which surrounds the gland, and the pressure is thus rendered inconceivably slight. Mr. Darwin conjectures that it may be less than the millionth of a grain. While the pressure may be extremely slight, it needs must be steady. A sharp, sudden brush of the tentacles does not induce inflection, nor do drops of water falling upon the glands from any height. This specialized nature of the sensitiveness may readily be seen to be of great use to the plant, effecting an economy of time and energy, for the process of inflection is slow and that of reëxpansion still slower, often occupying many hours, and even days. It should be mentioned that, when excited by soluble matter of the proper kind, not only the tentacles, but the disks, are inflected and close in about the object. There is thus formed out of the leaf a stomach; a comparison that Mr. Darwin has proved to be no fanciful one. Space will not permit giving even examples of his exhaustive experiments; to the book itself must be referred those who may doubt their thoroughness, or question the conclusions drawn from them.

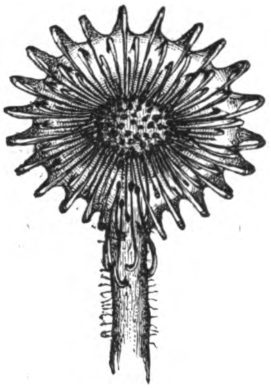

FIG. 8.—DROSERA ROTUNDIFOLIA.—Leaf (enlarged) with all the tentacles closely inflected.

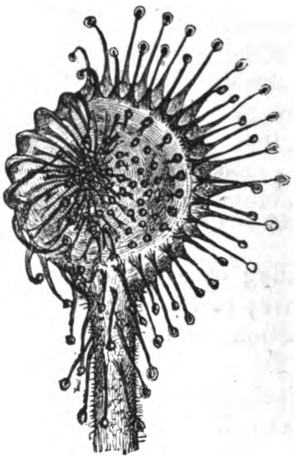

FIG. 4.—DROSERA ROTUNDIFOLIA.—Leaf (enlarged) with the tentacles on one side inflected over a bit of meat.

It is proved that the leaves are capable of true digestion, and that the glands absorb the digested matter. The correspondence between the secretion of the *Drosera* and the gastric juice of animals is shown in that which it fails to digest as well as that which it succeeds in digesting. As is well known, the gastric juice contains an acid and a ferment, both of which are requisite for digestion; so it is with the secretion of *Drosera.* When the stomach of an animal is mechanically irritated, it secretes an acid; when bits of glass are put on the glands of *Drosera,* the secretion and that of the surrounding glands are increased in quantity and become acid. The stomach of an animal, however, does not secrete its proper ferment, pepsin, until certain substances called peptogenes are absorbed; matter must be absorbed by the glands of *Drosera* before they secrete their proper ferment. Like gastric juice, the secretion of *Drosera* has antiseptic properties. Meat is dissolved by each in the same manner and by the same stages. It promptly dissolves cartilage, a substance so little affected by water. It dissolves bone, and even the enamel of teeth. In short, there is no doubt that the ferment in both cases is closely similar if not identically the same, a fact in physiology which may well be called wonderful!

When it is considered where the plant grows—generally on extremely poor, peaty soil—it is evident that the supply of nitrogen would be quite deficient unless the plant had the power of obtaining this important element from captured insects, and we can thus understand how its roots are so poorly developed. These usually consist of only two or three slightly divided branches from half to one inch in length, furnished with absorbent hairs: it appears that they serve only to imbibe water, though, of course, they will absorb nitrogenous matter when supplied.

Confirmation of these statements is furnished by some experiments, concluded since the publication of Mr. Darwin's book, by Mr. Lawson Tait, an account of which he sends to *Nature*, July 29, 1875, p. 251. Only the results can be stated, and those briefly: "It is certain that the sundew not only absorbs nutriment by its leaves, but that it can actually live and thrive by their aid alone (that is, without the aid of roots); that nitrogenous matter is more readily absorbed by the leaves than by the roots, for over-feeding kills the plant sooner by the leaves alone than by the roots alone."

Mr. Tait also announces that from the secretion of *Drosera dichiotoma* he has been able to separate a substance closely resembling pepsin.

If a tentacle receives an impulse from its own glands the movement is always toward the centre of the leaf (Fig. 5).

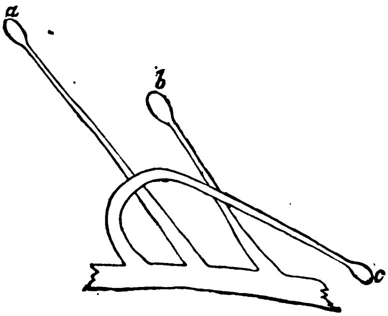

FIG. 5.—DROSERA ROTUNDIFOLIA.—Diagram showing one of the exterior tentacles closely inflected; the two adjoining ones in their ordinary position.

On the other hand, when the motor impulse comes from one side of the disk, the surrounding tentacles, including the short central ones, all bend with precision toward the point of excitement, wherever this may be seated. This is in every way a remarkable phenomenon; for the leaf falsely appears as if endowed with the senses of an animal (*see* Fig. 4).

In every case the impulse from a gland has to travel for at least a short distance to the basal part of the tentacle, the gland being carried solely by the inflection of the lower part. When the central glands are stimulated, and the extreme marginal tentacles become inflected, the motor impulse is transmitted across half the diameter of the disk. It passes not along the vascular system, but through the cellular tissue, traveling more rapidly and easily in a longitudinal than in a transverse line, probably for the reason that the cells are elongated longitudinally, and some obstruction is encountered at each cell-wall through which the motor impulse must pass.

A molecular change of the protoplasm within the cells, to which Mr. Darwin has given the name of aggregation, precedes and accompanies all motion. When a leaf which has not been excited or inflected is examined, the cells forming the pedicels are seen to be filled with an homogeneous purple fluid. If the tentacle be examined some hours after having been excited, the purple matter is found to be aggregated into masses of various shapes suspended in a colorless fluid. The change begins within the glands and travels downward, being arrested for a short time at each cell-wall; the aggregated masses perpetually changing form, separating and uniting. After the cause of the excitement has been removed, and the tentacles have reëxpanded, the colored masses of protoplasm are redissolved, and the purple fluid again becomes homogeneous and transparent. This process of aggregation is not dependent upon the inflection of the tentacles or increased secretion of the glands—a most remarkable feature of the phenomenon being that in the tentacles which are inflected by an indirect irritation, conveyed by motor impulse from other glands, some influence is sent up to the glands, as their secretion is increased and becomes acid; then the glands thus excited send back some other action, causing the protoplasm to aggregate in cell beneath cell. There can actually be seen a molecular change proceeding, which may be somewhat similar to the molecular change which is supposed to be sent from one end of a nerve to another when sensation is felt. We have here a reflex action, and the only known case thereof in the vegetable kingdom. The rate at which the motor impulse is transmitted is much slower than in animals. This fact, as well as that of the motor impulse not being specially directed to certain points, are both, no doubt, due to the absence of nerves. Nevertheless, we perhaps see the prefigurement of the formation of nerves in animals in the transmission of the motor impulse being much more rapid down the confined space within the tentacles than elsewhere, and somewhat more rapid in a longitudinal than in a transverse direction across the disk.

Of course, there is not in this, or in the reflex action, any thing comparable with the nervous systems of animals, and, as Mr. Darwin says, "the greatest inferiority of all is the absence of a central organ, able to receive impressions from all points, to transmit their effects in any definite direction, to store them up and reproduce them." That is to say, *Drosera* seems to be without even the prefigurement of a brain, and we can almost fancy that we detect a trace of disappointment or regret in this admission.

A wide range of experiment shows that probably all the species of *Drosera* are adapted for catching and digesting insects by nearly the same means, though not with equal development or completeness.

Dionæa muscipula.—The form of the bilobed leaf which is the most wonderful feature of this wonderful plant, already described, may be seen from the accompanying sketch.

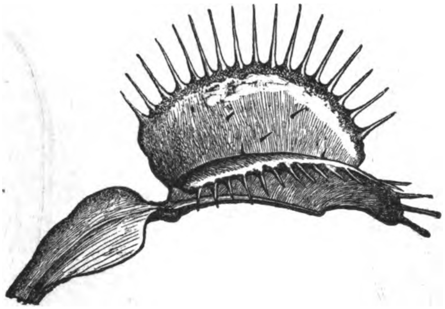

FIG. 6.—DIONÆA MUSCIPULA.—Leaf viewed laterally in its expanded state.

In the *Dionæa* the locality of sensitiveness is the three filaments which appear on each half of the upper surface of the leaf. It is unlike *Drosera* in that the filaments are sensitive to sudden impact, the transmission of the impulse is more rapid and the consequent movement instantaneous. Another point of unlikeness consists in the power of secretion of the glands, those of *Dionæa* being only excited by the absorption of nitrogenous matter. When any substance comes in contact with the filaments, the lobes of the disk close instantly upon it, confining it in a concave chamber; if the imprisoned matter be nitrogenous the lobes are gradually pressed closer together, the glands secrete freely and reëxpansion takes place only after from nine to twenty-four days, when nearly all trace of the substance will have disappeared, and sensitiveness is lost, only to reappear after some time has elapsed, if at all. If, however, the closing is the result of sudden impact or of the contact of a non-nitrogenous substance, the leaf shortly opens again and is at once sensitive, the glands showing no signs of secretion. The constitution and action of the secretion are identical with those of *Drosera*, as is probably the manner of transmission of the motor impulse. But want of space again excludes many interesting details.

Aldrovanda, *Drosophyllum*, *Roridula*, and *Byblis*, four other genera of the same order, all are provided with secreting glands and seem to have similar powers, though in a lesser degree.

Mr. Darwin was also led to investigate the habits of *Pinguicula* *vulgaris*, the result being to establish beyond question the predatory practices of the bladderwort, a plant which had hitherto enjoyed a good name.

It is not provided with any irritable filaments, the sensitiveness residing in the surface of the leaf, which is set with two kinds of glandular hairs secreting an extremely viscid fluid which seems to be the only agent for entrapping the insects. When once caught they are detained by the slowly-inflecting leaf. Here, too, contact with nitrogenous bodies changes the nature of the secretion, so that it becomes capable of dissolving and digesting insects and other nutritious substances, when the secretion and the digested matter are reabsorbed by the glands. When the objects are too large to be inclosed by the inflected leaf, they are by its incurving pushed along over the surface, constantly coming in contact with fresh and hungry glands, subserving the needs of the plants as well as by the other method (*see* Fig. 8).

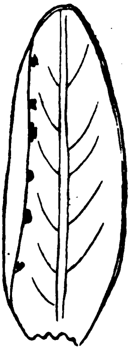

Fig. 7.—Pinguicula vulgaris.—Outline of leaf with left margin inflected over a row of small flies.

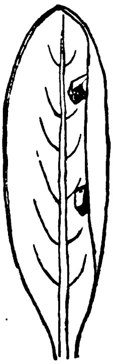

Fig. 8.—Pinguicula vulgaris.—Outline of leaf, with right margin inflected against two square bits of meat.

Utricularia neglecta and U. vulgaris (*common Bladderwort*).—It will be a new revelation to most readers to be told that the bladders of this plant are not, as the manuals have always stated, filled with air and intended to float the plant, but that their real use is to capture small aquatic animals, which they do on a large scale.

The general appearance of a bladder is shown in the figure (10) given below. The lower side is straight, the other surface convex and terminating in two long prolongations bearing six or seven long pointed bristles. The prolongations are called antennæ, for, as Mr. Darwin says, "the whole bladder curiously resembles the entomostracean crustacea" upon which they prey so freely.

Under these antennæ, where the bladder is slightly truncated, is situated the most curious and important part of the whole structure, namely, the entrance and valve.

The valve is attached on all sides to the bladder, excepting by its posterior margin, which is very thin, and rests on a collar or rim, which dips deeply into the bladder. The valve can only open inward; there are on its surface numerous glands, which have the power of absorption, but are not known to secrete.

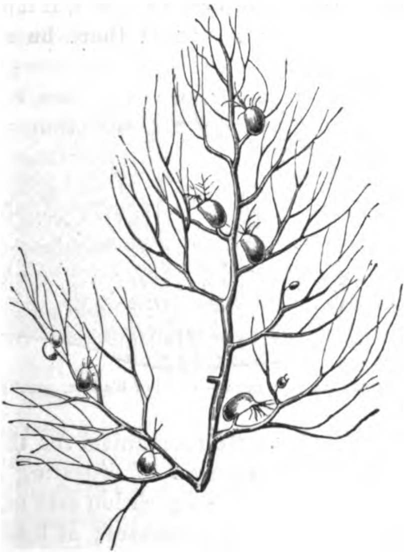

Fig. 9.—Utricularia neglecta.—Branch with the divided leaves bearing bladders; about twice enlarged.

The whole inner surface of the bladder is covered with a serried mass of processes, consisting each of four divergent arms, whence they are called quadrifid processes. Each arm generally contains a minute, faintly-brown particle, either rounded or elongated, which shows incessant Brownian movements.

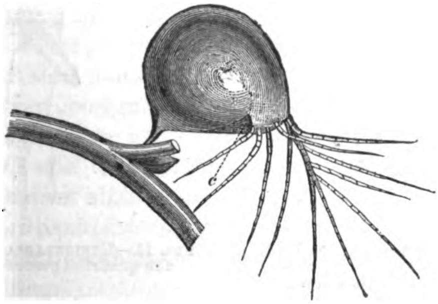

Fig. 10.—Utricularia neglecta.—Bladder, much enlarged.

Whenever found in stagnant water the bladders swarm with insects, crustaceans, larvæ, and fresh-water worms, in various stages of decay. The animals enter the bladder by bending in the free edge of the valve, which shuts again instantly. How it is that such weak and minute animals get into the bladders is not yet understood, but they do succeed in entering as do inanimate objects, if laid upon the valve. The locality of the irritability, if indeed there be any, is not determined.

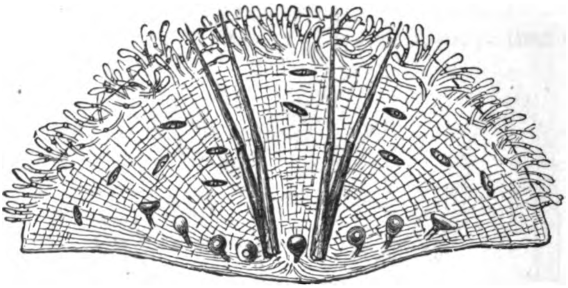

FIG. 11.—UTRICULARIA NEGLECTA.—Valve of bladder, greatly enlarged.

Notwithstanding the elaborate mechanism for the capture of animal food, there seems to be no power of digesting it, nor for hastening its decay; although, when decomposition sets in, its products are slowly absorbed by the quadrifid processes; at least, these processes from bladders containing decayed animals generally show masses of spontaneously-moving protoplasm which do not appear in those taken from clean bladders.

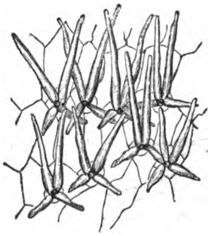

FIG. 12.—UTRICULARIA NEGLECTA.—Small portion of inside of bladder, much enlarged, showing quadrifid processes.

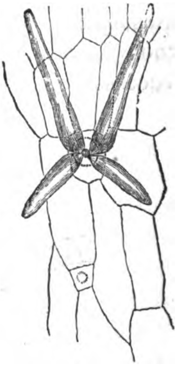

FIG. 13.—UTRICULARIA NEGLECTA.—One of the quadrifid processes greatly enlarged.

Investigations were extended to many other species of *Utricularia*, with results showing, in all cases, an adaptation for capturing small animals and power to absorb the products of their decay.

To be classed with this genus, as being insectivorous to a similar extent, are *Sarracenia* and *Darlingtonia*. Upon these Mr. Darwin records no observations.

Sarracenia variolaris has, however, had its powers carefully investigated by Dr. Mellichamp, of Bluffton, South Carolina. This species differs from the common Northern one (*S. purpurea*) chiefly in having a lid which closes over the mouth of the trumpet-shaped leaves, so that rain can not readily enter. The leaves are usually half-filled with a fluid which Dr. Mellichamp is satisfied is secreted at the bottom of the tubes. He describes it as mucilaginous, and leaving in the mouth a peculiar astringency. In it meat decomposes more rapidly than in water, and he concludes that as the leaves when stuffed with insects become most disgusting in odor, we have to do with an accelerated decomposition, though not with digestion. He attributes anæsthetic effects to the fluid. The lure which brings the insects to the mouth of the pitcher is a honey-baited pathway running from the ground along the broad wing of the pitcher to its mouth, up which the insects are lured to their fate. Nothing of this kind is observed in *S. purpurea*, and its exposed mouth is so placed that rain must fall into it. It is not probable, as Dr. Hooker says, that pitchers presenting such differences should act similarly, and he adds: "The fact that insects normally decompose in the fluid of all would suggest the probability that all feed on the products of decomposition; but as yet we are ignorant whether the glands within the pitchers are secretive or absorptive, or both; if secretive, whether they secrete water or a solvent; if absorptive, whether they absorb animal matter or the products of decomposition."

Prof. C. V. Riley (American Association for the Advancement of Science, 1874) is of opinion that the only benefit to the plant is from the liquid manure.

But this fascinating subject cannot be pursued further.

Sentimental flower-worshipers, fond of quoting the pretty metaphor of their buds and blossoms being "truly the language of angels," will doubtless be pained to learn that they are not all ethereal creatures subsisting on such lovely foods as dew and sunlight, but that they are at times given to dining off the more substantial fricassees which their alert tentacles know so well how to prepare. And although they may consign the sanguinary *Droseras* and *Dionæas* to the limbo of the unclean, and turn with renewed admiration to their own floral pets, still the matter does not end here. Mr. Darwin throws out some dark hints as to the private lives of the immaculate *Primula*, the brilliant *Pelargonium* and other greenhouse favorites, that must lead the thoughtful mind to conclude that that they will at least bear watching.

Seriously, these revelations afford abundant food for thought. There are three remarkable powers connected with the phenomenon: the movement of the leaves when excited; the secreting of a digestive fluid; the absorption of digested matter. The species possessing them all hold them in different degree; some possess two and others but one of them. What light can natural selection throw upon the steps by which these wonderful powers were gradually acquired? is one of the problems presented to the evolutionist.

Mr. Darwin submits his work wonderfully advanced when compared with the state in which he found it, but there remains much to be done.

INDUCED DISEASE FROM THE INFLUENCE OF THE PASSIONS.[1]

BY B. W. RICHARDSON, M. D., F. R. S.

MANY of the forms of disease previously detailed may be induced by other causes than worry or mental strain. They may be the effects of the unrestrained influence of certain of the passions. I say certain of the passions, because all do not seem to act with the same intensity. Some of them act with a sharpness of intensity that is peculiar, while others apparently excite no physical injury.

The passions which act most severely on the physical life are anger, fear, hatred, and grief. The other passions are comparatively innocuous. What is called the passion of love is not injurious until it lapses into grief and anxiety; on the contrary, it sustains the physical power. What is called ambition is of itself harmless; for ambition, when it exists purely, is a nobility lifting its owner entirely, from himself into the exalted service of mankind. It injures when it is debased by its meaner ally, pride; or when, stimulating a man to too strenuous efforts after some great object, it leads him to the performance of excessive mental or physical labor and to the consequences that follow such effort.

The passion called avarice, according to my experience, tends rather to the preservation of the body than to its deterioration. The avaricious man, who seems to the luxurious world to be debarring himself of all the pleasures of the world, and even to be exposing himself to the fangs of poverty, is generally placing himself in the precise conditions favorable to a long and healthy existence. By his economy, he is saving himself from all the worry incident to penury; by his caution he is screening himself from all the risks incident to speculation or the attempt to amass wealth by hazardous means; by his regularity of hours and perfect appropriation of the sunlight, in preference to artificial illumination, he rests and works in periods that precisely accord with the periodicity of Nature; by his abstemiousness in living he takes just enough to live, which is precisely the right thing to do according to the rigid natural law. Thus, in almost every particular, he goes on his way freer than other men from the external causes of all the induced diseases, and better protected than most men from the worst consequences of those diseases which spring from causes that are uncontrollable.

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[1] From advance sheets of a new work in press of D. Appleton & Co., entitled "The Diseases of Modern Life."

I do not hold up this picture as an encouragement to avarice, for an avaricious world would truly be a sad one. "But there is a soul of goodness in things evil, would men observingly distill it out," and, certainly, much goodness might be observed even in the perverted passion of avarice, if reckless and over-generous men would condescend to the distillation.

Some of the most extreme instances, at all events, nay, the most typical instances, of longevity with perfect physical health that I have met with, have been in those who are tinctured practically with the passion under consideration. It is true some have not been happy, and none eminently useful; but to the physiological mind they present a remarkable picture of the endurance of health and life under what are nearest to the natural conditions necessary for both. They suggest that if with this physical standard a higher and nobler mental development could be attained, with art and science and benevolent labors as the pleasures added to the life, the approach to perfection of existence would be closely realized, and the age, not of the man only but of the world of life to which he belongs, would be more thoughtfully conserved.

Of the passions I have enumerated as most detrimental to life, anger stands first. He is a man very rich indeed in physical power who can afford to be angry. The richest cannot afford it many times without insuring the penalty, a penalty that is always severe. What is still worse of this passion is, that the very disease it engenders feeds it, so that if the impulse go many times unchecked it becomes the master of the man.

The effects of passion are brought out entirely through disturbance in the organic nervous chain. We say a man was "red" with rage, or we say he was "white" with rage, by which terms, as by degrees of comparison, we express the extent of his fury. Physiologically we are then speaking of the nervous condition of the minute circulation of his blood: that "red" rage means partial paralysis of minute blood-vessels: that "white" rage means temporary suspension of the action of the prime mover of the circulation itself. But such disturbances cannot often be produced without the occurrence of permanent organic evils of the vital organs, especially of the heart and of the brain.

The effect of rage upon the heart is to induce a permanently perverted motion, and particularly that perverted motion called intermittency. One striking example, among others of this kind which I could name, was afforded me in the case of a member of my own profession. This gentleman told me that an original irritability of temper was permitted, by want of due control, to pass into a disposition of almost persistent or chronic anger, so that every trifle in his way was a cause of unwarrantable irritation. Sometimes his anger was so vehement that all about him were alarmed for him even more than for themselves, and when the attack was over there were hours of sorrow and regret, in private, which were as exhausting as the previous rage. In the midst of one of these outbreaks of short, severe madness, he suddenly felt, to use his own expression, as if his "heart were lost." He reeled under the impression, was nauseated and faint: then, recovering, he put his hand to his wrist, and discovered an intermittent action of his heart as the cause of his faintness. He never completely rallied from that shock, and to the day of his death, ten years later, he was never free from the intermittency. As a rule he was not conscious of the intermittency unless he took an observation on his own pulse, as though he were apart from himself: but occasionally after severe fatigue he would be subjectively conscious of it, and was much distressed and depressed. "I am broken-hearted," he would say, "physically broken-hearted." And so he was: but the knowledge of the broken heart tempered, marvelously, his passion, and saved him many years of a really useful life. He died ultimately from an acute febrile disorder.

The effect of anger upon the brain is to produce first a paralysis, and afterward, during reaction, a congestion of the vessels of that organ; for, if life continues, reactive congestion follows paralysis as certainly as day follows night. Thus, in men who give way to violent rage there comes on, during the acute period, what to them is merely a faintness, which, after a time of apparent recovery, is followed by a slight confusion, a giddiness, a weight in the head, a sense of oppression, and a return to equilibrium. They are happy who, continuing their course, suffer no more severely. Many die in one or other of the two stages I have named. They die in the moment of white rage, when the cerebral vessels and heart are paralyzed. Then we say they die of faintness, after excitement. Or, they die more slowly when the rage has passed and the congestion of reaction has led to engorgement of the vessels of the brain. Then the engorgement has caused stoppage of the circulation there; or a vessel has given way; or serous fluid has exuded, producing pressure, and we report that the death was from apoplexy, following upon some temporary excitement.

Hatred, when it is greatly intensified, acts much like anger in the effects it produces. The phenomena differ in that they are less suddenly developed and more closely concealed; they very rarely, in fact, come under the cognizance of the physician unmixed with other phenomena. They are made up of the symptoms of suppressed anger with morose determination, and they keep the sufferer from rest. He is led to neglect the necessities of his own existence; he is rendered feverish and feeble; and at last he either sinks into chronic despondency and irritability, or rushes hastily to the performance of some act which indicates disordered mind.

The effects of fear are all but indentical with those of rage, and like rage grow in force with repetition. The phenomena are so easily developed in the majority of persons, they may actually be acquired by imitation, and may be intensified and perhaps induced by listening to the mere narratives of events which act as causes of fear. I am daily more and more convinced that not half the evils resulting from what may be called the promptings of fear in the young and the feeble are duly appreciated, and that fear is the worst weapon of physical torture the thoughtless coward wields. The organs upon which fear exerts its injurious influence are, again, the organic nervous chain, the heart, and the brain.

Permanent intermittency of the heart is one of the leading phenomena incident to sudden and extreme terror. One example, sufficiently characteristic, will illustrate this fact:

A gentleman of middle age was returning home from a long voyage in the most perfect health and spirits, when the vessel in which he was sailing was struck from a collision, and, hopelessly injured, began to sink. With the sensation of the sinking of the ship and the obvious imminence of death—five minutes was the longest expected period of remaining life—this gentleman felt his heart, previously acting vehemently, stop in its beat. He remembered then a confused period of noise and cries and rush, and a return to comparative quiet, during which he discovered himself being conveyed, almost unconsciously, out of the sinking vessel on to the deck of another vessel that had rendered assistance. When he had gained sufficient calmness he found that periods of intermittent action of his heart could be counted. They occurred four and five times in the minute for several days, and interfered with his going to sleep for many nights. On reaching land the intermittency decreased, and when the patient came to me, soon afterward, there were not more than two intermittent strokes in the minute, all the intervening strokes being entirely natural and the action of the heart and the sounds of it being simply perfect. In this gentleman the intermittent pulse became a fixed condition, but so modified in character that it was endurable. At his last visit to me he was not conscious of the symptom except he took it objectively from himself, by feeling his own pulse or listening to his own heart.

The effect of fear on the brain may be to the extent of that which is produced by extremity of rage, so that even sudden death, from syncope, may ensue. I have known two such instances as these, but the more common effect is an intense irritability, followed by doubt, suspicion, and distrust, leading toward or to insanity. From a sudden terror deeply felt the young mind rarely recovers, never, I believe, if hereditary tendency to insanity be a part of its nature. A man, who is now the inmate of an asylum, owing to fixed delusions that all his best friends are conspiring to injure and kill him, explained to me, before his delusion was established, from what it started. When he was a boy he had a nervous dread of water, and his father, for that very reason, and with the best of intentions, determined that he should be taught to swim. He was taken by his tutor, in whom he had every confidence, to the side of a river, and when he was undressed he suddenly found himself cast by his instructor, without any warning, into the stream. No actual danger of drowning was implied, for the tutor himself was at once in the water to hold him up or to bring him to land; but the immediate effect, beginning with the faintness of fear, was followed by vomiting, by a long train of other nervous symptoms, by constant dread that some one was in some way about to repeat the infliction, by frequent dreaming of the event by night, by thinking upon it in the day. At last all the phenomena culminated in that breach between the instinctive and the reasoning powers which we, for want of a better term, call dangerous and insane delusion.

The effect of grief varies somewhat according to the suddenness or slowness with which it is expressed. Sudden grief tells chiefly upon the heart, leading to irregular action, and to various changes in the extreme parts of the circulation incidental to such irregularity. Under sudden impulse of grief I have known singular local manifestations of disease, as for instance the development of a *goître;* an hæmoptysis or loss of blood from the lungs; a local paralysis of the lip and tongue; a failure of sight.

When the grief is less sudden and more prolonged, want of power and intermittency of the circulation are again the most common phenomena. They are most easily developed in women, but I have seen them occur even in men of strong habit but sensitive feeling. Thus a gentleman whom I know well, and who suffers in the way I describe, tells me that he first became conscious of the intermittency in the action of his heart, upon the anxiety he felt from the loss of one of his brothers, to whom he was deeply attached and for whose superior talents he had, as indeed many others had, a profound admiration. The attacks at first were so severe that they created in his mind some alarm; but in course of time he became accustomed to them, and the sense of fear passed away. The intermittency in this instance alternated with periods in which there was very slight interruption of natural action. During the more natural periods there was, however, an occasional absence of stroke once in two or three hundred beats, but the fact was not evident to the subject himself. When the extreme attacks were present the intermittency of pulse occurred six or even seven times in the minute, and the fact, which was subjectively felt, was very painful. The stomach at the same time was uneasy, there were flatulency and a sensation of sinking and exhaustion. In the worst attacks there was also some difficulty in respiration, and a desire for more capacity for air, but unattended by spasm or acute pain. A severe attack was induced readily by any cause of disturbance, such as broken rest or mental excitement; on the other hand, rest and freedom from care seemed to him curative, for a time.

In this gentleman another symptom was presented for one or two years, which is somewhat novel, and exceedingly striking. The symptom was this: When the intermittent action of the heart was at its worst, there came on in the fingers of one or other hand a sensation of coldness and numbness, followed instantly by quick blanching of the skin, precisely the same appearance, in fact, as is produced when the surface of the body is frozen. The numbness and temporary death of the parts would often remain for a full hour, during which time the superficial sensibility was altogether lost. When recovery commenced in the fingers it was very rapid, and after recovery no bad results were ever noticeable. I have since seen one similar illustration in another individual, occurring under nearly similar circumstances.

From the irregularity of the circulation of the blood induced by prolonged grief, varied central phenomena in the nervous matter follow, and in persons who have passed middle life these phenomena are usually permanent if not progressive. They consist of organic feebleness extending to all the active organs of the body, and affecting specially the mental organism. A constant desire for rest, for avoidance of cares, for seclusion, mark this stage of disease, if so it may be called. It is not necessarily a stage leading to rapid failure of further physical or mental power, for the mind and body are subdued so equally that there is no galling irritability, no wearing depression from the influence of other passions. The worst that happens ultimately in those instances is the gradual but premature encroachment of dementia previous to death, if the life be prolonged to its natural term.

Under some circumstances the passions, excited in turn, injure by the combined influence of their action. In games of chance where money is at stake we see the play of the worst passions in all its mischievous intensity. Fear and anger, hate and grief, hope and exultation, stand forth, one after the other, keeping the trepitant heart in constant excitement and under tremulous strain, until at length its natural steadiness of motion is transformed into unnatural irregularity which, if it do not remain permanent, is called up by the slightest irritation. The act of playing at whist for high stakes is a frequent source of disease from this cause. I know that professed or habitual card-players declare that, however much may be played for, the losses and winnings of games are equalized by turn, and that after a year's play the player has, practically, neither won nor lost. I may accept that what is declared on this point is true; but the fact, if it be one, does not alter the physical evil that results, one iota. The man who, after being engaged in business all day, sits down regularly at night to play his rubbers on rubbers, to stake heavily on his games, to bet on his odd tricks, never, I believe, escapes the effects of organic nervous shock. Some of the worst forms of such shock I have seen have sprung from this cause.

Political excitements call forth readily the reel of the passions with dangerous energy. A few specially constructed men, who have no passions, pass through active political excitement and, maybe, take part in it without suffering injury; but the majority are injured. As they pour forth their eloquent or rude speeches, as they extol or condemn, as they cheer or hiss, as they threaten or cajole, they are taking out of themselves force they will never regain.

It has been observed since the time of Pinel, that when to political excitement there is added the excitement of war, especially of civil war, the effects on the physical life of the people is at once marked by the disturbance of nervous balance. This fact was forcibly illustrated during and after the last great civil war in America, and it formed the subject of several most able reports by the physicians of that country. One report, by Dr. Stokes, of the Mount Hope Institution of Baltimore, was, I remember, a masterly history which, when the time comes that war shall be no more, will be read with as much wonder as we now read of the witch or dancing mania of the middle ages. One victim of the war mania is cursed with fear until he fails to sleep; another believes all his estates are confiscated; a third imagines himself taking part in some bloody fray; a fourth, the subject of aural delusions, no sooner sleeps than he wakes up, roused by what he considers to be awful sounds afar off, but approaching nearer. These are the more visible evidences of the injuries of war beyond those inflicted on the fighting-men. They represent much, but they represent little if they be compared with the minor but still formidable physical injuries to the heart and brain which stop short of real insanity, but which reduce life, and which pass in line from the generation that receives them primarily to the generations that have to come.

The reel of the passions as a cause of diseases of modern life rests not with the excitements of gaming, of political strife, of war. It is stirred up by some fanatical manifestations for the regeneration of the world, which are well meant, but which, missing the mark, plant degeneration instead.

In a sentence, whenever, from undue excitement of any kind, the passions are permitted to overrule the reason, the result is disease: the heart empties itself into the brain; the brain is stricken, the heart is prostrate, and both are lost.

THE PROPERTIES OF PROTOPLASM.[1]

BY ERNST HAECKEL,
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THE term protoplasm, from Gr. πρῶτος, *first*, and πλάσμα, *form*, is applied to the supposed original substance from which all living beings are developed, and which is the universal concomitant of every phenomenon of life. All that is comprehended for brevity under the term life, whether the growth of plants, the flight of birds, or a train of human thought, is thus supposed to be caused by corporeal organs which either themselves consist of protoplasm, or have been developed out of it. Wherever nutrition and propagation, motion and sensation exist, there is as their material basis this substance designated in a general sense as protoplasm. The proof of it is held to be furnished by the protozoans called moners, the whole completely developed body of which consists solely of protoplasm. They are not only the simplest organisms with which we are acquainted, but also the simplest living beings we can conceive of as capable of existing; and though their entire body is but a single, formless, small lump of protoplasm, and (each molecule of it being like the other) without any combination of parts, yet they perform all the functions which in their entirety constitute in the most highly-organized animals and plants what is comprehended in the idea of life, namely, sensation and motion, nutrition and propagation. By examining these moners we shall gain a clear conception of the nature of protoplasm, and understand the important biological questions connected with the theory.

Some moners live in fresh water, and others in the sea. They are as a rule invisible to the naked eye, but some are as large as the head of a pin, and may be distinguished without the aid of a microscope. When completely at rest a moner commonly assumes the shape of a simple sphere. Either the surface of the body is quite smooth, or numerous exceedingly delicate threads radiate from it in all directions. These threads are not permanent and constant organs of the slime-like body, but perishable continuations of it, which alternately appear and disappear, and may vary every moment in number, size, and form. For this reason they are called false feet or pseudopodia. Nevertheless, by means of these pseudopodia the moners perform all the functions of the higher animals, moving them like real feet either to creep, climb, or swim. By means of these sticky threads they adhere to foreign bodies as with arms, and by shortening or elongating them they drag their own bodies after them. Each thread, like the whole body, is capable of being contracted, and every portion of it is as sensitive and excitable as the entire form. When any point on the surface of the body is touched with the point of a pin, or with another body producing a chemical alteration, as for example a small drop of acid, or when a current of electricity is passed through it, the threads are drawn in, and the entire body contracts into the form of a spherical lump. The same threads perform also the function of providing alimentation.

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[1] From the forthcoming volume of Appletons' "American Cyclopædia."

When a small infusorium or any other nutritive particle comes accidentally in contact with the extended pseudopodia, these run quickly over it like a fluid, wind around it with their numerous little branches, fuse into one, and press it into the interior of the body, where all the nutritive portions are rapidly absorbed and immediately assimilated, while all that is useless is quickly ejected.

The variations among the different moners, of which so far sixteen kinds have been described (Haeckel's "Monographie der Moneren)," consist partly in the various forms of the pseudopodia, but especially in the different kinds of propagation. Some of them merely divide into halves on reaching a certain size; others put forth little buds which gradually separate from them; and others experience a sudden division of the mass into numerous small spherical bodies, each of which instantly begins a separate existence and gradually reaches the size of the ancestral organism.

The chemical examination of the homogeneous protoplasmic body shows that it consists throughout of an albuminous or slime-like mass, hence of that azotic carbonate of the character of the highly-compounded connective group called proteine, albuminoids, or plasson bodies. Like other chemical compounds of this group, protoplasm exhibits several reactions which distinguish it from all others. It is easy to detect it under the microscope, on account of the facility with which it combines with certain coloring matters, as carmine and aniline; it is colored dark yellow or yellowish brown by iodine and nitric acid; and it is coagulated by alcohol and mineral acids, as well as by heat. The quantitative composition of protoplasm, though in some cases greatly varying, resembles as a whole that of other albuminoids, and hence consists of from fifty to fifty-five per cent. of carbon, probably six to eight of hydrogen, fifteen to seventeen of nitrogen, twenty to twenty-two of oxygen, and one to two of sulphur. Protoplasm possesses the quality of absorbing water in various quantities, which renders it sometimes extremely soft and nearly liquid, and sometimes hard and firm like leather; but it is usually of a medium degree of density. Its more prominent physical qualities are excitability and contractility, which Kühne and others have made a special subject of investigation.

On examining with the microscope the numerous substances constituting the various organs of the higher animals, it appears that they all consist of a large number of minute elements, known since Schleiden and Schwann (1838) by the name of cells; and in these cells protoplasm is the oldest, most primordial, and most important constituent. In every real cell there is, besides protoplasm, and while still alive and independent, a second important constituent, the cellular germ, so called (nucleus or cytoblast); but even this germ consists of an albuminous chemical compound which is closely related to protoplasm, and was orginally produced from it by an exceedingly slight chemical alteration. The germ is usually a smaller and firmer formation within the protoplasm of the cell.

Inasmuch as the idea of an organic cell, as now adopted by histologists, rests on the presence of two different essential parts in this elementary organism, the internal cell and the external protoplasm, we must distinguish also two different kinds of elementary organisms: germless cytods, as moners for example, and the real germ-inclosing cells, which originate from the former by secreting in the interior of the small mass of protoplasm a true germ or nucleus. Cells of the simplest kind consist only of protoplasm with a nucleus, while in general the cells of animal or vegetable bodies have also other constituents, particularly and frequently an inclosing skin or capsule (the cellular membrane), also crystals, grains of fat, pigments, and the like, within the protoplasm. But all of these parts came into being only secondarily through the chemical action of protoplasm; they are but the internal and external products of protoplasm. (Haeckel's "Generelle Morphologie," vol. i., p. 279). The single cell of the simplest kind is able to exist as an independent organism. Many of the lowest plants and animals, and also many neutral *protista* (which are neither animals nor plants), retain for life the character of a simple cell. Such unicellular organisms of the simplest kinds are the *amœbæ*, found in large numbers as well in fresh as in salt water. Amœbæ are simple naked cells of various and varying forms. The whole difference between them, especially *protamœbæ*, and certain moners, is that they have a germ. It is probable that this germ of the amœbæ (as may be supposed to be the case with many and perhaps all other cells) is only an organ of propagation, and hence of heredity; while all the other functions, alimentation, motion, and sensation, are performed by the protoplasm. This seems to indicate that at the reproduction of the cells, which is usually effected by segmentation, it is the germ which first divides in two, and that the protoplasm afterward gathers around each of the two sister germs till it also falls in two. It is impossible to distinguish from the common amœbæ the cellular ovules of many of the inferior animals, as for example the sponges, medusæ, and other plant-like animals. With these the eggs are simple naked cells, which, with the sponges especially, sometimes crawl about independently in the body of the animal, giving rise to the idea that they were a class of parasitic amœbæ. But with other animals also, and with most plants, the eggs of which generally obtain subsequently special and often very complicated encasements and other additions, every egg is originally a simple cell. The seminal elements of the male are also only simple cells, and the entire mysterious process of fructification is after all nothing but the fusion or concrescence of two different cells, the one a female egg-cell, and the other a male semen-cell. In consequence of this fusion the germs of the two combined cells dissolve, and therewith the young, newly-generated individual begins his existence as a simple cytod, or a small germless ball of protoplasm. But inside of this cytod soon arises a new germ, which turns it again into a cell, and this simple cell forms by oft-repeated segmentation an accumulation of cells. Out of this heap are produced by secretion certain germinal layers or "germ-leaves," and out of these proceed all the other organs of the complete being. Each of these organs again originally consists only of cells, and in all of these cells the essential constituent parts are only the germ and protoplasm: the germ as the elementary organ of propagation and heredity, protoplasm as the elementary organ of all the other functions, sensation, motion, alimentation, and adaptation. Cells and cytods, therefore, are true elementary organisms, independent minute forms of life, which either in the lowest existences continue to live independently, or in the higher organisms combine in numbers to form a community. Cells and cytods are the veritable "formers" of life, or plastids. The most ancient and primordial forms of plastids are cytods, the whole body of which consists of protoplasm, in which the germs are internally produced, and from which therefore the cells proceed.

As a matter of course, to the infinite varieties presented by the organic forms and vital phenomena in the vegetable and animal kingdom, corresponds an equally infinite variety of chemical composition in the protoplasm. The most minute homogeneous constituents of this "life-substance," the protoplasm molecules, or plastidules, as they are called by Elsberg, must in their chemical composition present an infinite number of extremely delicate gradations and variations. The atoms of carbon, hydrogen, nitrogen, oxygen, and sulphur, which compose each of the plastidules, must enter into an infinite number of diverse stratifications and combinations. The chemistry of to-day, with its imperfect methods of investigation, is totally powerless before these intricate organic compounds, and it is possible only to surmise, from the infinitely varied physiological qualities of the numberless kinds of plastids, the infinite variety of plastidules out of which they are composed.

According to the plastid theory recently advanced, the great variety of vital phenomena is the consequence of the infinitely delicate chemical difference in the composition of protoplasm, and it considers protoplasm to be the sole active life-substance. This theory puts force and matter in living organisms into the same causal connection which has long been accepted for force and matter in inorganic bodies. This conception has been rapidly matured, especially in the past twenty years, through the more exact information obtained in regard to the lowest kinds of organisms. Yet the idea had been grasped more than half a century ago; for the "primordial slime" which Lorenz Oken proclaimed in 1809 to be the original source of life, and the material basis of all living bodies, possessed in all essentials the same qualities and the same importance now ascribed to protoplasm; and the *sarcode* so called, which in 1835 was pointed out by the French zoölogist Félix Dujardin as the only living substance in the body of rhizopods and other inferior primitive animals, is identical with protoplasm. But when Schleiden and Schwann, in 1838, developed their cell theory, they were not acquainted with the fundamental significance of protoplasm. Even Hugo Mohl, who in 1846 was the first to apply the name protoplasm to the peculiar serous and mobile substance in the interior of vegetable cells, and who perceived its high importance, was very far from understanding its significance in relation to all organisms. Not until Ferdinand Cohn (1850), and more fully Franz Unger (1855), had established the identity of the animate and contractile protoplasm in vegetable cells and the sarcode of the lower animals, could Max Schultze in 1858–'61 elaborate this protoplasm theory of the sarcode, so as to proclaim protoplasm to be the most essential and important constituent of all organic cells, and to show that the bag or husk of the cell, the cellular membrane, and the intercellular substances, are but secondary parts of the cell, and are frequently wanting. In a similar manner Lionel Beale (1862) distinguished such primary forming and secondary formed substances in all organic tissues, and gave to protoplasm, including the cellular germ, the name of "germinal matter," and to all the other substances entering into the composition of tissues, being secondary and produced, the name of "formed matter."

The protoplasm theory received a wide and thorough illustration from the study of rhizopods which Ernst Haeckel published in 1862 in his "Monographie der Radiolarien," and its complete application in the "Generelle Morphologie der Organismen" by the same naturalist. Haeckel distinguishes in these works, for the first time, between germless protoplasm, consisting only of plastids called cytods by him, and the germ-containing real cells, the elementary organism of which consists already of two different essential parts, germ and protoplasm. He conceived the cytods and cells as two different gradations of plastids, of organic elementary individuals, or as "individuals of the first order," and adopted entirely, in regard to the individual independence of the plastids, the ideas which had been set forth by Rudolf Virchow and Ernst Brücke.

Virchow, whose "Cellular-Pathologie" contains the most complete application of the cell theory to pathology, called the cells and the "cell territories" belonging to them the individual hearth or source of life; Brücke designated them as "elementary organisms." The plastids or individuals of the first order, identical with them, were determined by Haeckel phylogenetically, to the effect that cytods and cells must be distinguished as two essentially different orders of formation; i. e., that cells were phylogenetically produced in a secondary manner from homogeneous cytods by means of the secretion of a germ by the protoplasm. This distinction is important for the reason that many of the lowest orders of organisms have no germ in the protoplasm; such is the case especially with the moners. These simplest of organisms were first discovered by Haeckel in 1864, and described by him in 1868 in his "Monographie der Moneren." Cienkowski and Huxley also made valuable investigations of various moners. The latter discovered in 1868 the famous bathybius, a very remarkable kind of moner, which at immense depths covers the bottom of the sea in immeasurable numbers, and which consists of formless and variable protoplasm tissues of different sizes.

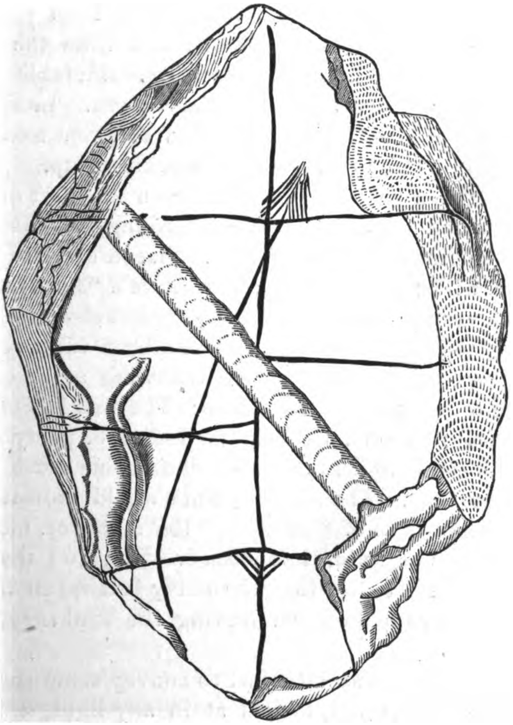
Among the moners investigated by Cienkowski, the most interesting are the vampire-cells, which are formless little bodies of protoplasm that bore into vegetable cells by means of their pointed pseudopodia, kill them, and absorb the protoplasm they find in them. On the basis of these discoveries Haeckel elaborated his plastid theory and carbon theory, which give the extremest philosophical consequences of the protoplasm theory.

In England the monistic philosophy of protoplasm has received the most weighty support from Huxley, whose "Protoplasm, or the Physical Basis of Life" (1868), put it in its true light, and called forth numerous writings for and against it. One of the most recent treatises in favor of it is that of James Ross "On Protoplasm" (1874). Probably the name of plasson will be given to the primordial, perfectly structureless, and homogeneous protoplasm of the moners and other cytods, in contradistinction to the protoplasm of germ-containing cells, which are produced only subsequently, by the differentiation of an internal nucleus and external protoplasm by the plasson bodies of moners. Édouard van Beneden especially calls for this distinction in his "Recherches sur l'évolution des grégarines;" and Haeckel has adduced new facts in favor of it in his "Monograpphie der Kalkschwämme." For the theory of "primordial generation," the spontaneous generation of the first vitality on earth, the distinction is of special importance, as the first organisms thus produced could have been only structureless specks of plasson, like the bathybius and other moners. The great theoretical difficulties formerly in the way of the theory of primordial or spontaneous generation have been removed by the discovery of the moners and the establishment of the plastid theory. As the protoplasm of the bathybius is not yet as much as individualized, while in the case of other moners there are individual lumps of constant sizes, it follows that the moners are to be regarded as the natural bodies which effect the transition from inorganic to organic Nature.

A CURIOUS INDIAN RELIC.

By CHARLES C. ABBOTT, M. D.

AMONG the several thousands of Indian relics gathered by the writer, in the immediate vicinity of Trenton, New Jersey, there has occurred one wholly different from all the others, and which bears some resemblance to the well-known Indian bark-letters, as figured by Schoolcraft and Catlin; but this inscribed stone is far more primitive than these. The specimen (as shown in the following diagram) is a slab of impure mica or micaceous slate, about an inch in thickness, seven inches in length, and four and three-fourths inches in greatest width. The edges have been rudely beveled, and the specimen chipped into its present shape previous to the inscribing of the peculiar markings which characterize the relic.



These consist of a series of well-defined lines, one extending the entire length of the specimen, and dividing it into two nearly equal parts or surfaces. There are also three well-defined lines crossing the central one at right angles, and a fourth short one, with "split" ends, on the left-hand side, below the centre of the slab.

The wide, shallow groove crossing obliquely from left to right is, I think, a subsequent marking, possibly from a ploughshare passing lightly over the stone. It has the appearance of having been done quite recently. Perhaps the most noticeable feature of the inscribed side of the stone is the well-defined arrow, extending obliquely across the specimen from right to left. This certainly helps one, at least, to imagine some plausible explanation of the meaning of the various markings.

The relic was found in a dense swamp, which until very lately has in no way been disturbed, otherwise than by cutting off the matured timber. Just where found it probably had been lying since the distant day when, for some purpose, it was placed in position by the aborigines.

That the specimen is really an Indian relic I am positive, having examined the spot where it was found; and from the fact that the lad that found it brought it to me with considerable doubt in his own mind as to its being really "Indian" work. In the immediate neighborhood were found quite a number of stone axes, spears, and arrow-points, all of them of the rudest workmanship.

As the specimen exhibits no attempt on the part of its primeval owner at ornamentation, not even polishing, it can scarcely be doubted that the markings upon it were placed there to express some fact to others who might find it; that it is a "bark-letter" written upon stone—a very primitive attempt at "picture-writing."

Admitting, then, that the specimen has been engraved, as we now find it, by an aborigine, I suggest the following as an explanation or interpretation of the various markings: The slab has been engraved and then placed in the trail which the Indian or party of them were following, with the long central line pointing due north or else in the direction of the trail. The crossing lines would indicate three days' journeys up to the time of "locating" the stone, or, more probably, that three streams of water had been crossed; and the direction of the arrow indicated the direction the party had taken from the point where the stone was placed, on leaving the trail they had been following.

That the specimen was intended to convey some such meaning, I have myself no doubt; but, looked at in any light, it is certainly a very remarkable form of "relic," and being (as yet) unique, in the enormous "find" from this neighborhood, I think goes to show it is really a "record" or "letter," as such "picture-writings" would naturally be made at rare intervals and under unusual circumstances.

The specimen is preserved in the Museum of the Peabody Academy of Science, at Salem, Massachusetts.

METEOROLOGY OF THE SUN AND EARTH.[1]

By Prof. BALFOUR STEWART, F.R.S.

SINCE the last meeting of the British Association, Science has had to mourn the loss of one of its pioneers, in the death of the veteran astronomer, Schwabe, of Dessau, at a good old age, not before he had faithfully and honorably finished his work. In truth, this work was of such a nature that the worker could not be expected long to survive its completion.

It is now nearly fifty years since he first began to produce daily sketches of the spots that appeared upon the sun's surface. Every day on which the sun was visible (and such days are more frequent in Germany than in this country), with hardly any intermission for forty years, this laborious and venerable observer made his sketch of the solar disk. At length this unexampled perseverance met with its reward in the discovery of the periodicity of sun-spots, a phenomenon which very speedily attracted the attention of the scientific world.

It is not easy to overrate the importance of the step gained when a periodicity was found to rule these solar outbreaks. *A priori* we should not have expected such a phenomenon. If the old astronomers were perplexed by the discovery of sun-spots, their successors must have been equally perplexed when they ascertained their periodicity. For while all are ready to acknowledge periodicity as one of the natural conditions of terrestrial phenomena, yet every one is inclined to ask what there can be to cause it in the behavior of the sun himself. Manifestly it can only have two possible causes. It must either be the outcome of some strangely hidden periodical cause residing in the sun himself, or must be produced by external bodies, such as planets, acting somehow in their varied positions on the atmosphere of the sun. But whether the cause be an internal or external one, in either case we are completely ignorant of its nature.

We can easily enough imagine a cause operating from the sun himself and his relations with a surrounding medium to produce great disturbances on his surface, but we cannot easily imagine why disturbances so caused should have a periodicity. On the other hand we can easily enough attach periodicity to any effect caused by the planets, but we cannot well see why bodies comparatively so insignificant should contribute to such very violent outbreaks as we now know sun-spots to be.

If we look within we are at a loss to account for the periodicity of solar disturbances, and if we look without we are equally at a loss to account for their magnitude. But, since that within the sun is hidden from our view, it cannot surely be considered blameworthy if astronomers have directed their attention to that without and have endeavored to connect the behavior of sun-spots with the positions of the various planets. Stimulated no doubt by the success which had attended the labors of Schwabe, an English astronomer was the next to enter the field of solar research.

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[1] **Opening Address in Section A, at the Bristol Meeting of the British Association.**

The aim of Mr. Carrington was, however, rather to obtain very accurate records of the positions, the sizes, and the shapes of the various sun-spots than to make a very extensive and long-continued series of observations. He was aware that a series at once very accurate and very extended is beyond the power of a private individual, and can only be undertaken by an established institution. Nevertheless, each sun-spot that made its appearance during the seven years extending from the beginning of 1854 to the end of 1860 was sketched by Mr. Carrington with the greatest possible accuracy, and had also its heliographic position, that is to say its solar latitude and longitude, accurately determined.

One of the most prominent results of Mr. Carrington's labors was the discovery of the fact that sun-spots appear to have a proper motion of their own—those nearer the solar equator moving faster than those more remote. Another was the discovery of changes, apparently periodical, affecting the disposition of spots in solar latitude. It was already known that sun-spots confined themselves to the sun's equatorial regions, but Mr. Carrington showed that the region affected was liable to periodical elongations and contractions, although his observations were not sufficiently extended to determine the exact length of this period.

Before Mr. Carrington had completed his seven years' labors, celestial photography had been introduced by Mr. Warren De la Rue. Commencing with his private observatory, he next persuaded the Kew Committee of the British Association to allow the systematic photography of the sun to be carried on at their observatory under his superintendence, and in the year 1862 the first of a ten years' series of solar photographs was begun. Before this date, however, Mr. De la Rue had ascertained, by means of his photoheliograph, on the occasion of the total eclipse of 1860, that the red prominences surrounding the eclipsed sun belong, without doubt, to our luminary himself.

The Kew observations are not yet finally reduced, but already several important conclusions have been obtained from them by Mr. De la Rue and the other Kew observers. In the first place the Kew photographs confirm the theory of Wilson that sun-spots are phenomena, the dark portions of which exist at a level considerably beneath the general surface of the sun; in other words, they are hollows, or pits, the interior of which is of course filled up with the solar atmosphere. The Kew observers were likewise led to associate the low temperature of the bottom of sun-spots with the downward carriage of colder matter from the atmosphere of the sun, while the upward rush of heated matter was supposed to account for the faculæ or bright patches which almost invariably accompany spots. In the next place the Kew observers, making use not only of the Kew series but of those of Schwabe and Carrington, which were generously placed at their disposal, have discovered traces of the influence of the nearer planets upon the behavior of sun-spots. This influence appears to be of such a nature that spots attain their maximum size when carried by rotation into positions as far as possible remote from the influencing planet —that is to say, into positions where the body of the sun is between them and the planet. There is also evidence of an excess of solar action when two influential planets come near together. But, although considerable light has thus been thrown on the periodicity of sun-spots, it ought to be borne in mind that the cause of the remarkable period of eleven years and a quarter, originally discovered by Schwabe, has not yet been properly explained. The Kew observers have likewise discovered traces of a peculiar oscillation of spots between the two hemispheres of the sun, and finally their researches will place at the command of the observers the data for ascertaining whether centres of greater and lesser solar activity are connected with certain heliocentric positions.

While the sun's surface was thus being examined both telescopically and photographically, the spectroscope came to be employed as an instrument of research. It had already been surmised by Prof. Stokes, that the vapor of sodium at a comparatively low temperature forms one of the constituents of the solar atmosphere, inasmuch as the dark line D in the spectrum of the sun coincides in position with the bright line given out by incandescent sodium-vapor.

This method of research was greatly extended by Kirchhoff, who soon found that many of the dark lines in the solar spectrum were coincident with the bright lines of sundry incandescent metallic vapors, and a good beginning was thus made toward ascertaining the chemical constitution of the sun.

The new method soon brought forth further fruit when applied in the hands of Huggins, Miller, Secchi, and others, to the more distant heavenly bodies. It was speedily found that the fixed stars had constitutions very similar to that of the sun. But a peculiar and unexpected success was attained when some of the nebulæ were examined spectroscopically. To-day it seems (so rapidly has knowledge progressed) very much like recalling an old superstition to remind you that until the advent of the spectroscope the irresolvable nebulæ were considered to be gigantic and remote clusters of stars, the individual members of which were too distant to be separated from each other even with a telescope like that of Lord Rosse. But Mr. Huggins, by means of the spectroscope, soon found that this was not the case, and that most of the nebulæ which had defied the telescope gave indications of incandescent hydrogen gas. It was also found by this observer that the proper motions of some of the fixed stars in a direction to or from the earth might be detected by means of the displacement of their spectral lines, a method of research which was first enunciated by Fizeau. Hitherto, in such applications of the spectroscope, the body to be examined was viewed as a whole. It had not yet been attempted to localize the use of this instrument so as to examine particular districts of the sun, as for instance a sun-spot, or the red flames already proved by De la Rue to belong to our luminary. This application was first made by Mr. Lockyer, who in the year 1865 examined a sun-spot spectroscopically, and remarked the greater thickness of the lines in the spectrum of the darker portion of the spot.

Dr. Frankland had previously found that thick spectral lines correspond to great pressure, and hence the inference from the greater thickness of lines in the umbra of a spot is that this umbra or dark portion is subject to a greater pressure; that is to say, it exists below a greater depth of the solar atmosphere than the general surface of the sun. Thus the results derived from the Kew photoheliograph and those derived from the spectroscope were found to confirm each other. Mr. Lockyer next caused a powerful instrument to be constructed for the purpose of viewing spectroscopically the red flames round the sun's border, in the hope that if they consisted of ignited gas the spectroscope would disperse, and thus dilute and destroy the glare which prevents them from being seen on ordinary occasions.

Before this instrument was quite ready these flames had been analyzed spectroscopically by Captain Herschel, M. Janssen, and others, on the occasion of a total eclipse occurring in India, and they were found to consist of incandescent gas, most probably hydrogen. But the latter of these observers (M. Janssen) made the important observation that the bright lines in the spectrum of these flames remained visible even after the sun had reappeared, from which he argued that a solar eclipse is not necessary for the examination of this region.

Before information of the discovery made by Janssen had reached this country, the instrument of Mr. Lockyer had been completed, and he also found that by its means he was able to analyze at leisure the composition of the red flames without the necessity of a total eclipse. An atmosphere of incandescent hydrogen was found to surround our luminary, into which, during the greater solar storms, sundry metallic vapors were injected—sodium, magnesium, and iron, forming the three that most frequently made their appearance.

Here we come to an interesting chemical question.

It had been remarked by Maxwell and by Pierce as the result of the molecular theory of gases that the final distribution of any number of kinds of gas in a vertical direction under gravity is such that the density of each gas at a given height is the same as if all the other gases had been removed, leaving it alone. In our own atmosphere the continual disturbances prevent this arrangement from taking place, but in the sun's enormously extended atmosphere (if, indeed, our luminary be not nearly all gaseous) it appears to hold, inasmuch as the upper portion of this atmosphere, dealing with known elements, apparently consists entirely of hydrogen. Various other vapors are, however, as we have seen, injected from below the photosphere into the solar atmosphere on the occasion of great disturbances, and Mr. Lockyer has asked the question, whether we have not here a true indication of the relative densities of these various vapors derived from the relative heights to which they are injected on such occasions.

This question has been asked, but it has not yet received a definite solution, for chemists tell us that the vapor densities of some of the gases injected into the sun's atmosphere on the occasion of disturbances are, as far as they know from terrestrial observations, different from those which would be indicated by taking the relative heights attained in the atmosphere of the sun. Mr. Lockyer has attempted to bring this question a step nearer to its solution by showing that the vapors at the temperatures at which their vapor densities have been experimentally determined are not of similar molecular constitution, whereas in the sun we get an indication, from the fact that all the elements give us line spectra, that they are in similar molecular states.

Without, however, attempting to settle this question, I may remark that we have here an interesting example of how two branches of science—physics and chemistry—meet together in solar research.

It had already been observed by Kirchhoff that sometimes one or more of the spectral lines of an elementary vapor appeared to be reversed in the solar spectrum, while the other lines did not experience reversal. Mr. Lockyer succeeded in obtaining an explanation of this phenomenon. This explanation was found by means of the method of localization already mentioned.

Hitherto, when taking the spectrum of the electric spark between the two metallic poles of a coil, the arrangements were such as to give an average spectrum of the metal of these poles; but it was found that, when the method of localization was employed, different portions of the spark gave a different number of lines, the regions near the terminals being rich in lines, while the midway regions give comparatively few.

If we imagine that in the midway regions the metallic vapor given off by the spark is in a rarer state than that near the poles, we are thus led to regard the short lines which cling to the poles as those which require a greater density or nearness of the vapor-particles before they make their appearance; while, on the other hand, those which extend all the way between the two poles come to be regarded as those which will continue to make their appearance in vapor of great tenuity.

Now, it was remarked that these long lines were the very lines which were reversed in the atmosphere of the sun. Hence, when we observe a single coincidence between a dark solar line and the bright line of any metal, we are further led to inquire whether this bright line is one of the long lines which will continue to exist all the way between two terminals of that metal when the spark passes.

If this be the case, then we may argue with much probability that the metal in question really occurs in the solar atmosphere; but if, on the other hand, the coincidence is merely between a solar dark line and a short bright one, then we are led to imagine that it is not a true coincidence, but something which will probably disappear on further examination. This method has already afforded us a means of determining the relative amount of the various metallic vapors in the sun's atmosphere. Thus, in some instances all lines are reversed, whereas in others the reversal extends only to a few of the longer lines.

Several new metals have thus been added to the list of those previously detected in the solar atmosphere, and it is now certain that the vapors of hydrogen, potassium, sodium, rubidium, barium, strontium, calcium, magnesium, aluminium, iron, manganese, chromium, cobalt, nickel, titanium, lead, copper, cadmium, zinc, uranium, cerium, vanadium, and palladium, occur in our luminary.

I have spoken hitherto only of telescopic spectroscopy; but photography has been found capable of performing the same good service toward the compound instrument consisting of the telescope and its attached spectroscope, which it had previously been known to perform toward the telescope alone. It is of no less importance to secure a permanent record of spectral peculiarities than it is to secure a permanent record of telescopic appearances. This application of photography to spectrum observations was first commenced on a sufficient scale by Mr. Rutherford, of New York, and already promises to be one of the most valuable aids in solar inquiry.

In connection with the spectroscope I ought here to mention the names of Respighi and Secchi, who have done much in the examination of the solar surface from day to day. It is of great importance to the advancement of our knowledge, that two such competent observers are stationed in a country where the climate is so favorable to continued observation.

The examination of the sun's surface by the spectroscope suggests many interesting questions connected with other branches of science. One of these has already been alluded to. I may mention two others put by Mr. Lockyer, premising, however, that at present we are hardly in a position to reply to them. It has been asked whether the very high temperatures of the sun and of some of the stars may not be sufficient to produce the disassociation of those molecular structures which cannot be disassociated by any terrestrial means; in other words, the question has been raised, whether our so-called elements are really elementary bodies.

A third question is of geological interest. It has been asked whether a study of the solar atmosphere may not throw some light upon the peculiar constitution of the upper strata of the earth's surface, which are known to be of less density than the average interior of our planet.

If we have learned to be independent of total eclipses as far as the lower portions of the solar atmosphere are concerned, it must be confessed that as yet the upper portions—the outworks of the sun—can only be successfully approached on these rare and precious occasions. Thanks to the various government expeditions dispatched by Great Britain, by the United States, and by several Continental nations—thanks, also, to the exertions of Lord Lindsay and other astronomers —we are in the possession of definite information regarding the solar corona.

In the first place, we are now absolutely certain that a large part of this appendage unmistakably belongs to our luminary, and in the next place, we know that it consists, in part at least, of an ignited gas giving a peculiar spectrum, which we have not yet been able to identify with that of any known element. The temptation is great to associate this spectrum with the presence of something lighter than hydrogen, of the nature of which we are yet totally ignorant.

A peculiar physical structure of the corona has likewise been suspected. On the whole, we may say that this is the least known, while it is perhaps the most interesting, region of solar research; most assuredly it is well worthy of further investigation.

If we now turn our attention to matters nearer home, we find that there is a difficulty in grasping the facts of terrestrial meteorology no less formidable than that which assails us when we investigate solar outbreaks. The latter perplex us because the sun is so far away, and because also his conditions are so different from those with which we are here familiar; while, on the other hand, the former perplex us because we are so intimately mixed up with them in our daily lives and actions; because, in fact, the scale is so large and we are so near. The result has been that until quite recently our meteorological operations have been conducted by a band of isolated volunteers individually capable and skillful, but from their very isolation incapable of combining together with advantage to prosecute a scientific campaign. Of late, however, we have begun to perceive that, if we are to make any advance in this very interesting and practical subject, a different method must be pursued, and we have already reaped the first fruits of a more enlightened policy; already we have gained some knowledge of the constitution and habits of our atmosphere.

The researches of Wells and Tyndall have thrown much light on the cause of dew. Humboldt, Dové, Buys Ballot, Jelinek, Quetelet, Hansteen, Kupffer, Forbes, Welsh, Glaisher, and others, have done much to give us an accurate knowledge of the distribution of terrestrial temperature. Great attention has likewise been given to the rainfall of Great Britain and Ireland, chiefly through the exertions of one individual, Mr. G. J. Symons.

To Dové we are indebted for the law of rotation of the wind, to Redfield for the spiral theory of cyclones, to Francis Galton for the theory of anti-cyclones, to Buchan for an investigation into the disposition of atmospheric pressure which precedes peculiar types of weather, to Stevenson for the conception of barometric gradients, to Scott and Meldrum for an acquaintance with the disposition of winds which frequently precedes violent outbreaks; and, to come to the practical application of laws, we are much indebted to the late Admiral Fitzroy and the system which he greatly helped to establish for our telegraphic warnings of coming storms.

Again, the meteorology of the ocean has not been forgotten. The well-known name of Maury will occur to every one as that of a pioneer in this branch of inquiry. Fitzroy, Leverrier, Meldrum, Toynbee, and others, have likewise done much; and it is understood that the meteorological offices of this and other maritime countries are now busily engaged upon this important and practical subject. Finally, the movements of the ocean and the temperatures of the oceanic depths have recently been examined with very great success in vessels dispatched by her Majesty's government; and Dr. Carpenter has by this means been able to throw great light upon the convection-currents exhibited by that vast body of water which girdles our globe.

It would be out of place to enter here more minutely into this large subject, and already it may be asked what connection has all this with that part of the address that went before it.

There are, however, strong grounds for supposing that the meteorology of the sun and that of the earth are intimately connected together. Mr. Broun has shown the existence of a meteorological period connected apparently with the sun's rotation; five successive years' observations of the barometer at Singapore all giving the period 25.74 days. Mr. Baxendell, of Manchester, was, I believe, the first to show that the convection-currents of the earth appear to be connected somehow with the state of the sun's surface as regards spots; and still more recently, Mr. Meldrum, of the Mauritius Observatory, has shown by a laborious compilation of ships' logs, and by utilizing the meteorological records of the island, that the cyclones in the Indian Ocean are most frequent in years when there are most sun-spots. He likewise affords us grounds for supposing that the rainfall, at least in the tropics, is greatest in years of maximum solar disturbance.

M. Poey has found a similar connection in the case of the West Indian hurricanes; and, finally, Piazzi Smyth, Stone, Köppen, and still more recently, Blanford, have been able to bring to light a cycle of terrestrial temperature having apparent reference to the condition of the sun.

Thus, we have strong matter-of-fact grounds for presuming a connection between the meteorology of our luminary and that of our planet, even although we are in complete ignorance as to the exact nature of this bond.

If we now turn to terrestrial magnetism, the same connection becomes apparent.

Sir Edward Sabine was the first to show that the disturbances of the magnetism of the earth are most violent during years of maximum sun-spots. Mr. Broun has shown that there is likewise a reference in magnetic phenomena to the period of the sun's rotation about his axis, an observation recently confirmed by Hornstein; and still more recently, Mr. Broun has shown that the moon has an action upon the earth's magnetism which is not altogether of a tidal nature, but depends, in part, at least, upon the relative position of the sun and moon.

I must trust to your forbearance if I now venture to bring forward considerations of a somewhat speculative nature.

We are all familiar with the generalization of Hadley, that is to say, we know there are under-currents sweeping along the surface of the earth from the poles to the equator, and upper-currents sweeping back from the equator to the poles. We are likewise aware that these currents are caused by the unequal temperature of the earth; they are in truth convection-currents, and their course is determined by the positions of the hottest and coldest parts of the earth's surface. We may expect them, therefore, to have a reference not so much to the geographical equator and poles as to the hottest and coldest regions. In fact, we know that the equatorial regions, into which the trade-winds rush and from which the anti-trades take their origin, have a certain annual oscillation depending upon the position of the sun, or, in other words, upon the season of the year. We may likewise imagine that the region into which the upper-currents pour themselves is not the geographical pole, but the pole of greatest cold.

In the next place we may imagine that these currents, as far as regards a particular place, have a daily oscillation. This has, I believe, been proved as regards the lower-currents or trade-winds, which are more powerful during the day than during the night, and we may therefore expect it to hold good with regard to the upper-currents or anti-trades; in fact, we cannot go wrong in supposing that they also, as regards any particular place, exhibit a daily variation in the intensity with which they blow.

Again, we are aware that the earth is a magnet. Let us not now concern ourselves about the origin of its magnetism, but rather let us take it as it is. We must next bear in mind that rarefied air is a good conductor of electricity; indeed, according to recent experiments, an extremely good conductor. The return-trades that pass above from the hotter equatorial regions to the poles of cold, consisting of moist rarefied air, are therefore to be regarded in the light of good conductors crossing lines of magnetic force; we may therefore expect them to be the vehicle of electric currents. Such electric currents will of course react on the magnetism of the earth. Now, since the velocity of these upper-currents has a daily variation, their influence, as exhibited at any place upon the magnetism of the earth, may be expected to have a daily variation also.

The question thus arises, Have we possibly here a cause which may account for the well-known daily magnetic variation? Are the peculiarities of this variation such as to correspond to those which might be expected to belong to such electric currents? I think it may be said that, as far as we can judge, there is a likeness of this kind between the peculiarities of these two things, but a more prolonged scrutiny will of course be essential before we can be absolutely certain that such currents are fitted to produce the daily variation of the earth's magnetism.

Besides the daily and yearly periodic changes in these upper convection-currents we should also expect occasional and abrupt changes forming the counterparts of those disturbances in the lower strata with which we are familiar. And these may be expected in like manner to produce non-periodic occasional disturbances of the magnetism of the earth. Now, it is well known that such disturbances do occur; and, further, that they are most frequent in those years when cyclones are most frequent; that is to say, in years of maximum sun-spots. In one word, it appears to be a tenable hypothesis to attribute at least the most prominent magnetic changes to atmospheric motions taking place in the upper regions of the atmosphere where each moving stratum of air becomes a conductor moving across lines of magnetic force; and it was Sir William Thomson, I believe, who first suggested that the motion of conductors across the lines of the earth's magnetic force must be taken into account in any attempted explanation of terrestrial magnetism.

It thus seems possible that the excessive magnetic disturbances which take place in years of maximum sun-spots may not be directly caused by any solar action, but may rather be due to the excessive meteorological disturbances which are likewise characteristic of such years. On the other hand, that magnetic and meteorological influence which Mr. Broun has found to be connected with the sun's rotation points to some unknown direct effect produced by our luminary, even if we imagine that the magnetic part of it is caused by the meteorological. Mr. Broun is of opinion that this effect of the sun does not depend upon the amount of spots on his surface.

In the next place, that influence of the sun, in virtue of which we have most cyclones and greater meteorological disturbance in the years of maximum spots, cannot, I think (as far as we know at present), be attributed to a change in the heating power of the sun. We have, no doubt, traces of a temperature effect which appears to depend upon the sun-period, but its amount is very small, whereas the variation in cyclonic disturbance is very great. We are thus tempted to associate this cyclone-producing influence of the sun with something different from his light and heat. As far, therefore, as we can judge, our luminary would appear to produce three distinct effects upon our globe. In the first place, a magnetic and meteorological effect, depending somehow upon his rotation; secondly, a cyclonic effect, depending somehow upon the disturbed state of his surface; and, lastly, the well-known light and heat effect with which we all are familiar.

If we now turn to the sun, we find that there are three distinct forms of motion which animate his surface-particles. In the first place, each particle is carried round by the rotation of our luminary. Secondly, each particle is influenced by the gigantic meteorological disturbances of the surface, in virtue of which it may acquire a velocity ranging as high as one hundred and thirty or one hundred and forty miles a second; and lastly, each particle, on account of its high temperature, is vibrating with extreme rapidity, and the energy of these vibrations communicated to us by means of the ethereal medium produces the well-known light and heat effect of the sun.

Now, is it philosophical to suppose that it is only the last of these three motions that influences our earth, while the other two produce absolutely no effect? On the contrary, we are, I think, compelled, by considerations connected with the theory of energy, to attribute an influence, whether great or small, to the first two as well as to the last.

We are thus led to suppose that the sun must influence the earth in three ways, one depending on his rotation, another on his meteorological disturbance, and a third by means of the vibrations of his surface-particles.

But we have already seen that, as a matter of fact, the sun does appear to influence the earth in three distinct ways—one magnetically and meteorologically, depending apparently on his period of rotation; a second cyclonically, depending apparently on the meteorological conditions of his surface; and a third, by means of his light and heat.

Is this merely a coincidence, or has it a meaning of its own? We cannot tell, but I may venture to think that, in the pursuit of this problem, we ought to be prepared at least to admit the possibility of a threefold influence of the sun.

Even from this very meagre sketch of one of the most interesting and important of physical problems, it cannot fail to appear that while a good deal has already been done, its progress in the future will very greatly depend on the completeness of the method and continuity of the observations by which it is pursued. We have here a field which is of importance not merely to one, or even to two, but almost to every conceivable branch of research.

Why should we not erect in it a sort of science-exchange, into which the physicist, the chemist, and the geologist, may each carry the fruits of his research, receiving back in return some suggestion, some principle, or some other scientific commodity that will aid him in his own field? But to establish such a mart must be a national undertaking, and already several nations have acknowledged their obligations in this respect.

Already the German Government have established a Sonnenwarte, the mere building and equipment of which is to cost a large sum. With an appreciation of what the spectroscope has done for this inquiry, the first directorship was offered to Kirchhoff, and, on his declining it, Herr Vogel has been placed in charge. In France, also, a physical observatory is to be erected at Fontenay, on an equal, if not greater scale, of which Janssen has already accepted the directorship; while in Italy there are at least three observatories exclusively devoted to this branch of research. Nor must we forget that in this country the new observatory at Oxford has been so arranged that it can be employed in such inquiries. But what has England as a nation done?

Some years since, at the Norwich meeting of this Association, a movement was set on foot by Colonel Strange, which resulted in the appointment of a royal commission on the advancement of science, with the Duke of Devonshire as chairman. This commission have quite recently reported on the steps that ought in their opinion to be taken for the advancement of scientific research.

One of their recommendations is expressed in the following words:

> "Important classes of phenomena relating to physical meteorology and to terrestrial and astronomical physics require observations of such a character that they cannot be advantageously carried on otherwise than under the direction of Government. Institutions for the study of such phenomena should be maintained by the Government; and, in particular, an observatory should be founded specially devoted to astronomical physics."

If the men of science of this country who procured the appointment of this commission, and who subsequently gave evidence before it, will now come forward to support its recommendations, it can hardly be doubted that these will be speedily carried into effect.

But other things besides observations are necessary, if we are to pursue with advantage this great physical problem.

One of these is the removal of the intolerable burden that has hitherto been laid upon private meteorologists and magneticians. Expected to furnish their tale of bricks, they have been left to find their own straw. Nothing more wretched can be imagined than the position of an amateur—that is to say, a man who pursues science for the love of it, and is unconnected with any establishment—who has set himself to promote observational inquiries, whether in meteorology or magnetism.

He has first to obtain with great expenditure of time or money, or both, copies of the individual observations taken at some recognized institution. He has next to reduce these in the way that suits his inquiry; an operation again consuming time and demanding means. Let us suppose all this to be successfully accomplished, and a valuable result obtained. It is doubtless embodied in the transactions of some society, but it excites little enthusiasm, for it consists of something which cannot be repeated by every one for himself like a new and interesting experiment. Yet the position of such men has recently been improved. Several observatories and other institutions now publish their individual observations; this is done by our Meteorological Office, while Dr. Bergsma, Dr. Neumayer, and Mr. Broun, are recent examples of magneticians who have adopted this plan. The publication of the work of the latter is due to the enlightened patronage of the Rajah of Travancore, who has thus placed himself in front of the princes of India, and given them an example which it is to be hoped they will follow. But this is only one step in the right direction; another must consist in subsidizing private meteorologists and magneticians in order to enable them to obtain the aid of computers in reducing the observations with which they have been furnished. The man of science would thus be able to devote his knowledge, derived from long study, to the methods by which results and the laws regulating them are to be obtained; he could be the architect and builder of a scientific structure without being forced to waste his energies on the work of a hodman.

Another hindrance consists in our deficient knowledge as to what observations of value in magnetism and meteorology have already been made. We ought to have an exhaustive catalogue of all that has been done in this respect in our globe, and of the conditions under which the various observations will be accessible to outside inquirers. A catalogue of this kind has been framed by a committee of this Association, but it is confined to the dominions of England, and requires to be supplemented by a list of that which has been done abroad.

A third drawback is the insufficient nature of the present facilities for the invention and improvement of instruments, and for their verification.

We have, no doubt, advanced greatly in the construction of instruments, especially in those which are self-recording. The names of Brooke, Robinson, Welsh, Osler, and Beckley, will occur to us all as improvers of our instruments of observation. Sir W. Thomson has likewise adapted his electrometer to the wants of meteorology. Dr. Roscoe has given us a self-recording actinometer, but a good instrument for observing the sun's heat is still a desideratum. It ought likewise to be borne in mind that the standard mercurial thermometer is by no means a perfect instrument.

In conclusion, it cannot be doubted that a great generalization is looming in the distance—a mighty law we cannot yet tell what, that will reach us, we cannot yet say when. It will involve facts hitherto inexplicable, facts that are scarcely received as such because they appear opposed to our present knowledge of their causes. It is not possible perhaps to hasten the arrival of this generalization beyond a certain point; but we ought not to forget that we *can* hasten it, and that it is our duty to do so. It depends much on ourselves, our resolution, our earnestness; on the scientific policy we adopt, as well as on the power we may have to devote ourselves to special investigations, whether such an advent shall be realized in our day and generation, or whether it shall be indefinitely postponed. If governments would understand the ultimate *material* advantages of every step forward in science, however inapplicable each may appear for the moment to the wants or pleasures of ordinary life, they would find reasons patent to the meanest capacities for bringing the wealth of mind, now lost on the drudgery of common labors, to bear on the search for those wondrous laws which govern every movement, not only of the mighty masses of our system, but of every atom distributed throughout space.—*Nature.*

SUICIDE IN LARGE CITIES.

BY ALLAN McLANE HAMILTON, M. D.

THE increased importance attached to the study of the relations of mind and body (the impetus to such study we have to thank Mr. Maudsley for) enables us to pursue our examination of certain psychical states to greater advantage than in former years. The investigation of suicide is now made much more clear as regards both the motive, behavior, and characteristics of the individual who takes his own life, and by the antecedents of his previous health, and other physical influences.

The object of this paper is to discuss the prevalence of this crime in large cities, its causes both moral and physical, and certain sanitary conditions which affect them. My observations have been made for the most part in New York, the largest city of the continent, and, as the most cosmopolitan, it offers an interesting field for research. I have made comparisons between the statistics of London and Paris, and, although it is impossible to obtain the most recent records of these two cities, I think a few hints may be gained that will be of value in preventing its increase. Statistics do not give us definite information upon the questions of heredity, cerebral injuries, neuroses, or other valuable aid in drawing conclusions, so that many important links are left out of the chain.

In all large cities the number of suicides is governed, to a great extent, by the habits, tastes, and moral culture of the people, and, back of this, by the national characteristics. For example, the French, notorious for their indifference to life, their general volatility, frequent political troubles, and exaggerated morbid sentimentality, are celebrated for the propensity to end life by their own hands.

Paris has been, and always will be, celebrated for the prevalence of this crime. The late Forbes Winslow, in his "Anatomy of Suicide," called particular attention to this national failing of the French. They pursue it as an agreeable mode of getting relief from their troubles, and, from the statesman, who blows his brains out to escape political disgrace, to the *grisette* of former days, who shut herself up with her little pan of charcoal, to seek oblivion from her ruin, the crime is a general one. Montesquieu, on the other hand, asserted that the English are notably a suicidal race, and that London, with its fogs and cheerlessness, is more of a city for suicides than Paris. Forbes Winslow denied this, and demonstrated that fogs had no influence whatever upon suicides; or, at least, that there were fewer suicides in foggy months than in more pleasant ones. Our own statistics substantiate this, as will be shown further on, and the months of April, May, June, July, and August, really the most pleasant of the year as regard sunshine, are those in which more people kill themselves.

The gravity and stolidity of the English people would rather show in their favor as regards this crime. In the year 1810 the number of suicides in London amounted to 188. Comparison with French statistics of the same year proved that five times as many Parisians as Londoners took this means for ending their days. French statistics show the excessive mortality from this cause. In the year 1806, 60 suicides were reported in Rouen, an extremely small city; in 1793, 1,300 in Versailles. Paris, from 1827 to 1830, furnished 6,900 suicides, an average of nearly 1.8 per year. In recent years, we have better statistical returns to work upon.

In the year 1858 the population of London was 2,720,607, and the number of suicides 283. The youngest of these was ten years, and the oldest eighty-five. In Paris, in 1853, the population was 1,053,262. There were 463 suicides, an immense number in excess of London several years later. In Turin, from 1855 to 1859, there were 108 suicides, making an average of 21 a year. In Rome, in 1871, there were only 15 suicides, showing that self-murder is very uncommon among the Italians. In the city of New York, between the years 1866 and 1872, there were 678 suicides, being an increase of 100 in the last year over the first; 511 males, 167 females. For the three years, 1870, 1871, and 1872, there were 359 suicides, 132 being Germans, a very large percentage. As regards matrimonial condition during these years, I find there were 17 married persons, 118 single, 43 widows and widowers, and 27 whose condition was not stated: 275 were males and 84 were females; the age of the oldest was eighty-six, and that of the youngest ten.

The cause for the suicide of the latter was remarkable. She was detected in a theft of fifty cents, by her mother, and, to seek escape from her shame, took Paris-green. The months in which suicide was most prevalent were those of summer. In August, 1870, there were 15 suicides, while in December only 7. In June, the following year, there were 14, and July of 1872 shows 20, and December only 4.

In regard to occupation, clerks commit suicide the most frequently, about 34 in 1870, 1871, and 1872, and but 10 laborers in the same time. The percentage of laborers abroad is greater than any other. The mode of suicide most often employed in the city of New York is that of poisoning—212 out of nearly 600 persons have died from some form of poisoning. The preference seems to be for arsenic; usually its commonest form—Paris-green. In 1872, of 50 poisoning cases, 22 took Paris-green; the others chose either opium, carbolic acid, or other irritants. In 1871, 14 took Paris-green. Nearly all of the suicides chose violent and painful poisons, there being but few exceptions. One individual ended his days by hydrate of chloral; the other, a druggist, with prussic acid. Three took chloroform. Shooting ended the lives of 147 persons; 135 hung themselves. In only one or two instances was any ingenuity shown in the suicides: one of these individuals first shot himself, and then jumped out of the window; the other threw himself in front of an advancing locomotive. In London, hanging seems to have been the method most in vogue, for, in the year 1858, 56 persons perished in this way.

A. Brierre de Boismont, in his "Recherches Médico-Légale sur Suicide," Paris, 1859, collected 4,595 cases, carbonic-acid gas and drowning being the favorite modes for self-murder with men, and strangulation with women. Of 463 suicides occurring in the year 1853, 92 men perished by carbonic-acid gas, 93 by drowning, and 131 women died by strangulation. The more ancient statistics show that voluntary starvation was a common form of suicide in the beginning of this century. The motive for suicide in the reported cases was extremely difficult to discover. Of the 463 cases in Paris in 1853, insanity produced the suicide of 53 men, 37 women; drunkenness, 48 men, 14 women; misery and grief, 20 men, 8 women; disappointed love, 28 men, 20 women; shame, 18 men, 9 women; domestic trouble, 18 men, 15 women; weariness of life, 20 men, 7 women; disease, 27 men, 19 women; fear of the law, 16 men, 2 women; ill-luck, 23 men, 14 women; trouble with parents, 5 men, 5 women; loss of situation, 8 men; loss of parents, 1 woman. By this table, it will be seen that insanity causes the largest number of suicides, both of men and women; drunkenness comes next, and disease third.

In regard to the form of suicide with fire-arms, Boismont shows, by a carefully-arranged table, that the greatest number shoot themselves in the mouth, seventy-five per cent. choosing this means.

Out of 368 cases, 234 shot themselves in the mouth, 71 in the abdomen and thorax, 26 in the temple, and but 1 in the ear, thus showing a knowledge of the vital parts of the body. In illustration of the coolness and resolution of these suicides, he found that 85 left wills. The chirography of letters and various communications written before death was steady and natural, not betraying any signs of weakness, trembling, or irresolution on the part of the writers. Parisian statistics prove that of 3,518 cases, 2,094 occurred in the daytime, 766 in the evening, and 658 at night, proving that daylight is most agreeable for this kind of work. The ages at which suicide seems to be most often resorted to are between forty and fifty among the men, and forty-five and fifty-five among the women.

The greatest number of suicides in the city of New York, as I have said, are by poison, and this mode of self-destruction being the favorite one, we are naturally led to inquire why it should be so. When we take into consideration the looseness of our present laws regarding the sale of poisonous drugs, and the comparative ease by which suicides can procure the agents for their destruction, we have very little cause for wonderment. The number of cases of accidental death which have occurred through the criminal carelessness of certain druggists, who deal the most deadly drugs to persons unknown to them, is worthy of serious comment. There appears to be no difficulty for the would-be suicide to buy just what poison he desires. A large proportion of the inhabitants of great cities are confirmed in certain pernicious habits. Among them are opium-eating and chloroform-taking, which they pursue to what extent they choose, as these articles are always to be had.

It is needless to say that the opium-habit, like alcoholism, frequently leads to self-destruction.

In this country, upon several occasions, certain individuals have taken their own lives after insuring them, that the policy might be paid to the family of the suicide. This is an example of a very interesting psychical condition. Alcohol and its secondary effects have swelled the number of suicides, and the victims who have died by their own hands have been equally of the higher and the lower classes in this country. I think a great increase in the returns of mortality of this especial variety of suicide would be observed if the reporting physicians would conscientiously state the cause of death. The shame attached to the procedure, particularly among people of position, has prompted the return to be made of "meningitis," "cerebral congestion," or other diseases. Within the last two years, I can call to my mind the suicide of six people of high social position, caused by drink. This vice is perhaps not entirely characteristic of large towns, but the facility for indulgence of the habit, and the numerous ways of drinking in private, are more perfect in the cities.

In smaller places, there is a certain amount of contact with one's fellows, which makes him the cynosure of all eyes, should he indulge too freely. As I have before said, the busy life men lead in the metropolis, and the necessity for brain-stimulus, accelerate the *facilis descensus*. The disgrace of men in high position, impending ruin and other facts, will often prompt suicide as a mode of relief.

A form of suicide which figures largely in American statistics is, jumping from an elevation. This may be chosen by the individual as an effectual method, if he hesitates to select one, or may be the result of a momentary state of delirium produced by the surroundings. This latter is a common form in some European cities that contain high churches, monuments, or towers. I have myself experienced a morbid desire of this character, after an ascent of the Mountain Corcovado, in the harbor of Rio de Janeiro. When looking over a steep precipice upon this bay, two thousand or more feet below, I felt a strange restlessness and distention of the blood-vessels, with an irresistible desire to leap out into the clear air. This disappeared when I looked upon some object near by. A medical friend relates a case in his own experience. He went with an acquaintance up into a very high, unfinished public building. There was no evidence of insanity in his acquaintance. When my friend's back was turned, his companion jumped far out into the air, and fell mangled to the sidewalk. In France this form of suicide is a very common one, 45 individuals in the year 1820 having precipitated themselves from heights. In the year 1852, 16 men and 19 women chose this means of self-murder. So prevalent were those suicides, that the authorities refused admission to the Column Vendôme. As I have before said, this method is not an unusual one. In New York, between the years 1866 and 1872, there were 21 victims.

Dr. C. P. Russell, of New York, has informed me of a friend who is to such an extent the subject of the impulse to throw himself from heights, that he will never sleep upon the third or fourth floor of any dwelling.

The impulse to commit suicide with sharp-cutting instruments has been more common in the European cities than those of this country, and, in the majority of instances, suicide by these weapons has been resorted to by insane subjects.

A most important study in connection with this subject is the influence of the mode of life of the poorer classes. I allude more particularly to the tenement-house system—to the colonization of many thousand people in a limited space, much too small for them. They are brought together so, that every vice becomes, to a great degree, contagious. Bad examples are followed by the younger generation, and it is much easier for a seed of sin to take root here than one of virtue. Families of several nationalities are closely packed together in front and rear houses. Ground and labor are so expensive, in the larger cities particularly, that this mode of living is unavoidable.

Despite the earnest efforts of an efficient health board in the city of New York, many radical defects exist, and ventilation, light, and drainage, are defective in the extreme. Diseases of the nervous system, principally of the trophic character, exist to a great extent, as results of imperfect lighting and ventilating.

In the five years preceding 1872 the deaths from nervous diseases in New York averaged 3,155.8, and for the years 1871 and 1872 were over 6,000, an unusually large proportion, the number of deaths from all causes being 59,623. The vices attending the colonization of the working-class (a great many do not work) are contagious, the moral contact of the vicious with the pure is certain to occur, the ruin of young girls, and depression of tone, are powerful inducers of suicide.

The American people partake of the characteristics of their transatlantic brethren. They are impulsive, energetic, enterprising, emotional, liable to excessive mental depression or exaltation. We have all the different bloods of Europe in our veins. We lead, however, an individual life of our own, a life as original and striking as other startling peculiarities of our country. We live too fast; we make and lose fortunes in a day; we acquire professional educations in a few years which take ordinary individuals as many more to get the rudiments of in Europe. It is any thing but *festina lente* here. The seeds of every national soil are sown, and take root before we can employ measures to suppress them. Every thing that can excite the emotions, make tense the mental faculties, and suddenly relax them, is among us. Speculations and stupendous schemes, which in older countries take several heads instead of one to mature, crush down the nervous system of men who work themselves to death, hardly taking time to eat, meanwhile living upon stimulants to enable them to stand the strain.

There is another class—I allude to the poor. The newspaper accounts of the miserable suicide in his upper attic tell this story every day. These subjects are chiefly foreigners, deluded to this country by unfounded expectations of fortunes to be made.

Only a few days ago I read in one of the daily papers that it was not an uncommon occurrence for immigrants to ask of the officials at Castle Garden, in perfect good faith, positions as insurance officers, bank officers, and other unattainable positions.

Many thousand Italians were sent here by rascally agents in their own country several years ago. They were promised work by these individuals, but on their arrival found none. They reached New York in mid-winter, and many of them found their way into the workshops and almshouses. Misery and suffering were prevalent. Among immigrants, particularly the Germans, there is a great disposition to suicide, and physical suffering doubtless awakens any hereditary tendency that may lie dormant. A great percentage remain at the seaport, looking for work. New York is particularly affected in this way. Immigrants come here, probably in most instances from occupations much more steady and remunerative in comparison to any found here; tradespeople, skilled workmen, and mechanics, often commit suicide, who find it difficult to obtain employment, and finally hunger and disappointment drive them to this step.

The prevalence of strikes, and trades-unions, with their dangerous restrictions and foolish oaths of allegiance, are fruitful causes of suicide. Men are afraid to work in opposition to the threats of their fellow trades-unionists, and, as poverty stares them in the face and they become desperate, they commit suicide.

A necessary attendant upon increase in population is immorality, engendered by vice attendant upon civilization. The more depraved forms of theatrical amusement found at the low theatre halls, two or three of which now exist in New York, wipe out all of the original purity from the nature of the weak-minded spectators. The low songs at some of these places, abounding in *double entendres* and suggestive gestures, inflame the dormant instincts of lust in the minds of the deeply-interested audience.

Prostitution is a very easy way leading to suicide. The attendant vices of this class very soon destroy the mind. Opium-eating, inebriety, and snuff-chewing, are habits which nearly all prostitutes follow after a time. The classification of these causes of suicide and their victims is very incomplete, and prostitution is placed on the records in only one instance in 1871, 1872, and 1873, as the calling of the individual.

The prevalence of seduction in large cities is perhaps greater among the lower classes—the workers in factories and shops. Indeed, the chance for this crime among the many thousand young girls and men who are herded together indiscriminately in the large tobacco, hoop-skirt, paper-box, and other factories of great cities, is often made use of. Suicide follows ruin, though not in as many cases as it would in France. I do not doubt but that the large rivers, upon which most American cities are built, give up a great many bodies of unfortunates who end their moral ruin by suicide. In fact, the number of cases reported as "found drowned" may be assumed in general to be suicidal.

In our own cities, as I have before shown, clerks seem to be the class that most often take their own lives. This seems reasonable when we consider the peculiar careers of a great many of them—the temptations of vice, the struggles for situation and support, and the pitfalls of a large city.

How shall we prevent the increase of this crime which advances at the rate of 300 per cent. in seven years? What sanitary measures can be taken to defeat its moral and physical causes?

It is a stupendous undertaking. To reduce its statistics would require an attack upon our whole social system.

I have pointed out the rapidity of our way of living, the excessive and unnatural strain upon the brains of business and professional men. To diminish this would be an almost impossible task. I can only suggest a diminution of working hours, the necessity for regular meals and habits, and means to prevent large cities from being overstocked by the agricultural classes, who imagine themselves in these days particularly fitted for business and professional pursuits. We should abolish immoral entertainments, advertising quacks, so-called anatomical museums, and obscene and sensational literature, as far as possible.

Legislation should strictly regulate the sale of poisonous drugs, and the police should enforce the laws. Friends and relatives of excitable and nervous persons should be alive to the necessity of keeping from their reach razors, cutting instruments, and poisons. They should also endeavor, as far as possible, to prevent the formation of the opium-habit, self-administration of chloroform, and alcoholic indulgence.

Careful watch should be kept on all persons who go up into high public buildings, church-spires, and other eminences. Physicians should employ caution lest their patients should habitually indulge in some narcotic drug originally prescribed. The boards of health of the different cities cannot be over-zealous in suggesting means for the improvement of the dwellings of the poor. Air, light, and ventilation, should be provided, if possible, for these are absolutely necessary for nervous development and healthy cerebration. I have always considered the system of small dwellings, that has succeeded so well in Philadelphia and other cities, an inestimable boon to the working-classes. A healthier moral and physical tone is engendered, both by elevating the self-reliance of heads of families, and the abolition of moral contamination so prevalent in tenement-house life.

The establishment of bureaus and other agencies for procuring work for immigrants, freeing the cities from the surplus of these people, would prevent much desperation, misery, and self-destruction.

A HOME-MADE MICROSCOPE.

By JOHN MICHELS.

THE progress of science in recent times is in a great degree due to the employment of instrumental aids to observation; and whoever wishes to keep up with this advance, or indeed to gain an adequate notion of its extent and interest, can only do so by the use of similar means. In the study of chemistry, experiments and actual observation of the behavior of substances under various conditions, are indispensable; in physics, multifarious appliances for the illustration of principles are constantly required; in astronomy, the telescope is absolutely essential; and, in biology, vast departments can be brought within our reach only by the aid of the microscope. This latter instrument, especially, has a wide range of application. The investigations of the anatomist and physiologist cannot go on without it; the educated physician has it in daily use; the tradesman finds it an important aid in testing the purity of commodities; and the student in many departments of physical science is obliged to use it in his work. When to all these considerations we add that the manipulation of the microscope, for the purpose of ordinary observation, may be acquired without much difficulty, and that the instrument itself may be procured at a moderate cost, we have said enough to justify the assertion that every educated person ought to possess a microscope, even as he possesses a collection of books.

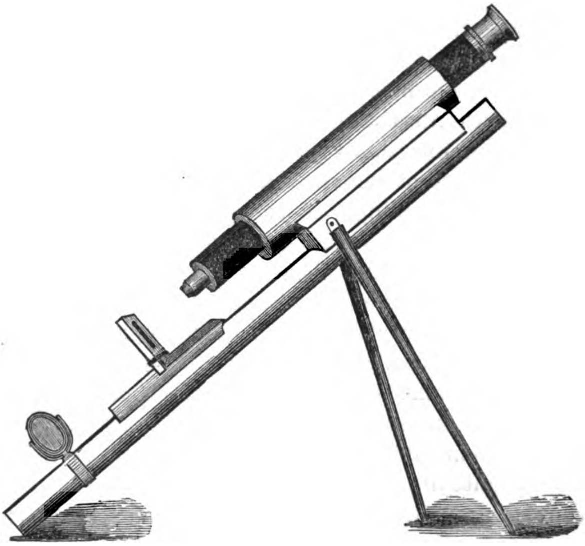

FIG. 1.—COMPLETE INSTRUMENT.

To derive advantage from the use of the microscope, it is not necessary that one should master all the technicalities of the instrument, or be possessed of all the improved appliances for extremely minute observations. Professional microscopists have recognized the error of directing all one's efforts on such tasks as the resolution of test-plates, so long as really urgent work remains undone. Thus, the President of the "Quekett Microscopical Society" remarked:

> "Our opticians have gone ahead of the observers, they have placed in our hands powerful means of research. I fear the account of the talent committed to our charge will not be one of which we may be proud. I fear we are too apt to pride ourselves as being the possessors of superior instruments; each man pits his instrument in rivalry against his neighbor's, and rejoices that he can beat him in the resolution of Nobert's test-plate."

Mr. Le Neeve Forster, in the above remarks, doubtless strikes at the root of an evil that is fast becoming a nuisance, to the utter detriment of useful and sound work; the test-slide and diatom fever has spread like an infection among all classes of microscopists, and has resulted in an extravagant system of expenditure foreign to true scientific research. I find that $1,650 is now asked for a first-class instrument and fittings, and as much as $40 apiece for diatom-slides.

These eccentricities of leading microscopists appear to have received protests from various quarters, for the President of the Royal Microscopical Society, in his last address, states:

> "It has been cast at us, as Fellows of this Society, that we do nothing but improve our tools, or measure the markings on the frustules of a diatom." [1]

One reason for the confessed poverty of microscopical results may be ascribed to the want of sufficient workers to cover so vast a field of research. It is to be regretted that many professional men, whose occupation would seem to demand the daily use of the microscope, deny themselves the facilities it offers. I apprehend that the explanation of this apparent neglect will be found in the high price asked for first-class instruments, and the absence in the market of a good standard instrument that combines the advantages of being of the best workmanship, full-sized, portable in form, and moderate in price.

Messrs. Baker, Crouch, Collins, and especially Swift, all of London, produce such microscopes, but, as their importation doubles the cost, their chief merit of cheapness is lost. In our own country, opticians have proved that they can produce work that cannot be surpassed, provided that their patrons entertain the same views as Sir Charles Surface respecting the expense; but those of more moderate means, who wish to purchase a good working microscope at a moderate cost, are offered a pretentious display of foreign and domestic forms, totally unfit for professional or scientific use. If makers of microscopes would take a lesson from the best telescope-makers, and, instead of multiplying the number of their models, combine their energy in the production of a good standard instrument, filling the conditions that I have already stated, they would promote the cause of science and concentrate their business.

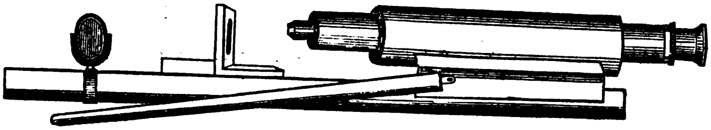

FIG. 2.—INSTRUMENT FOLDED FOR CARRIAGE.

Those who have read the biographical and obituary sketches of eminent microscopists have probably noticed that it was a favorite pursuit with many of them to make their own instruments. In the

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[1] February 3, 1875.

Monthly Microscopical Journal, for March last, will be found such a notice included in the address of the President of the Royal Microscopical Society, referring to the death of a Fellow, Mr. John Williams, who was also Assistant Secretary of the Royal Astronomical Society. He said:

> "He constructed more than one microscope out of odds and ends, which he put together with much skill and ingenuity. His most elaborate microscope was made with cardboard tubes and brass-screw adjustments. This instrument, when supplied with objectives by Ross and others, contrasted favorably, in point of utility, with constructions of a more costly character."

The perusal of this notice, followed by a communication to the effect that in some of the London scientific schools the students are required (when practicable) to make all the apparatus they use, has prompted me to describe a microscope made by myself about six years ago, and which is now but little the worse for wear.

So far as the stand is concerned, it can be easily made at home, at a trifling cost. The materials are of a humble character, but the optical arrangements are full-sized, and of the highest quality. Within the limits of its use this instrument will exhibit objects with much perfection. By a reference to the cuts, it will be observed that many of the parts are cylindrical, and may be turned on any ordinary lathe in a few minutes.

To make a microscope such as I shall now describe, requires little mechanical skill. If my directions are followed, and strict attention given to the drawings, no difficulty will be encountered, but neatness and precision are of course essential. First provide a wood rod about 15 inches long, and of the circumference of Fig. 3.

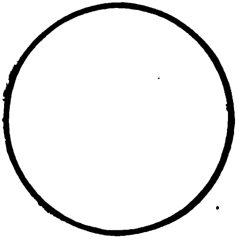

FIG. 3.

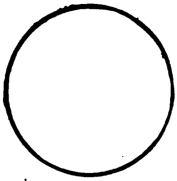

FIG. 4.

Then take some paper of firm texture, and wind it around the rod three or four times according to its thickness, applying mucilage all the time; immediately withdraw the paper casing, and place on one side to dry. This should form a perfectly true and firm tube. When dry, replace it on the rod, and with a sharp knife cut off from each end sufficient to leave the remainder 7½ inches long.

The other parts are of wood. I suggest mahogany as the most appropriate, and susceptible of the best finish; but any well-seasoned, hard wood will do.

To proceed, make a rod, like an ordinary ruler, 13½ inches long, and of the diameter of Fig. 4. Now turn, or get turned, a tube, 4½ inches long, the walls of which shall be ¼ of an inch thick; Fig. 5 will give the diameter.

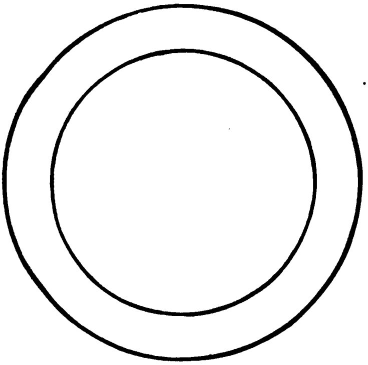

FIG. 5.

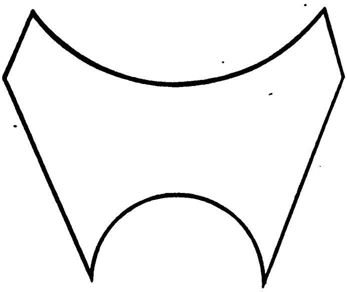

FIG. 6.

A part which I call the cradle can now be made; the form is shown in section, at Fig. 6; its length must be 3¾ inches.

The support for the stage requires no special explanation; a full-sized drawing is given at Fig. 7.

The stage itself can be made of wood, but gutta-percha is better, and, if placed in hot water, it can afterward be easily moulded to the pattern given at Fig. 9.

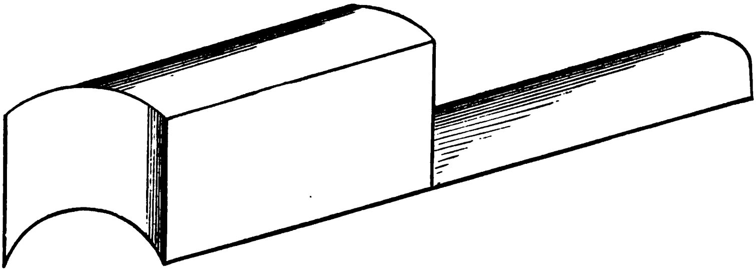

FIG. 7.

Smooth the surface while still warm with glass plates, and steady the back with two strips of wood. The shaded part at the lower edge shows a piece of wood fixed thereon to support a zoöphite trough or glass slides. Fig. 10 represents the upper and lower parts of a leg, two of which are required, 9¾ inches long, and the size shown in cut. On the upper portion the brass hinged attachment is fixed.

The appearance of the paper tube, with eye-piece and object-glass in position, can be seen at Fig. 11.

The parts which have been already described being completed, proceed to fix them together with glue. Their correct position can be seen at a glance by reference to Fig. 12.

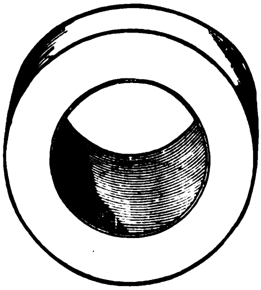

FIG. 8.

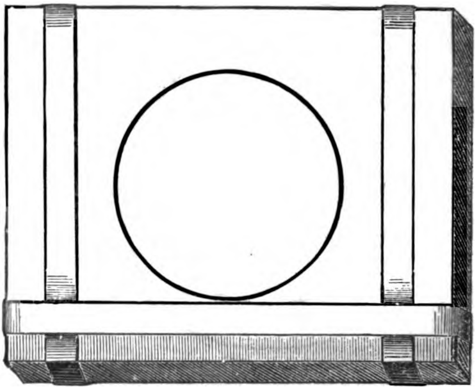

FIG. 9.

First fix the cradle, 6, upon the rod, 4—within three-quarters of an inch of the end—next the tube, 5, upon the cradle, as shown. The stage and support can next be fastened, but first insert the paper tube, Fig. 11, in wooden tube, 5, and measure the most convenient place to fix the stage, so that the object-glass can approach the object without bringing the tube too low down. A trial will at once fix the proper spot.

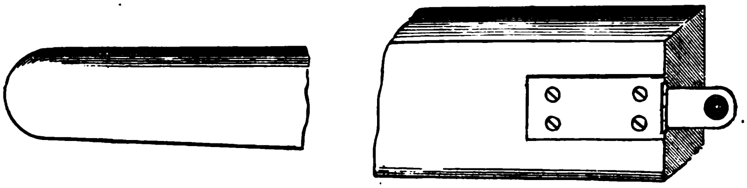

FIG. 10.

The legs are attached by screws to the cradle, as seen in Figs. 1 and 2. The whole being now in form, clean and French-polish.

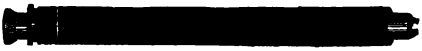

FIG. 11.

Also paint the inside of the paper tube a dull black, using drop-black, turpentine, and a little Japan varnish to fix color, and the outside with a mixture of Indian and common inks. Finally, line tube, 5, with a piece of fine cloth. If this is neatly done, the paper tube, Fig. 11, will pass and repass as smoothly as the motion of a telescope, which is controlled in a similar manner.

There is no reason why the optical parts should not be made by the student, but necessary instructions would require a series of articles. Assuming, therefore, that such portions will be purchased, a few words on that head may be necessary.

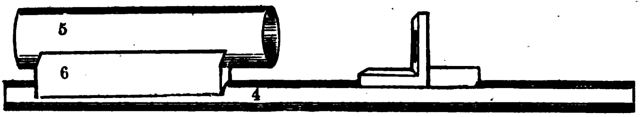

FIG. 12.

If only one eye-piece is required, select letter B. Next take tube, Fig. 11, to an optician, and ask him to fit a Royal Microscopical Society screw, Fig. 8, in the centre of a wood block. This block and screw must be fastened into one end of the paper tube, and will carry the object-glass.

The last fitting will be the mirror, a reduced drawing of which is shown at Fig. 13.

The mirror should be at least two inches in diameter, and the ring which passes over the rod, Fig. 4, should be split, and about half an inch in breadth, and, being made somewhat too small, will grip the rod, and be free from unsteady movement.

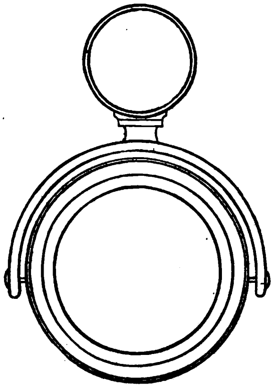

FIG. 13.

To hold the slide upon the stage in position, pass two moderate-sized India-rubber bands upon each side, and a third crosswise near the bottom; a very delicate movement can be given to a slide thus held.

In regard to object-glasses I have little to add. Such as I should have specially recommended are not to be obtained in this country;

but, to commence operations with, purchase the best 1-inch and ½-inch your means will permit. I much regret that the objectives made by Gundlach, of Berlin, are not introduced. It would be a boon to those who cannot afford to purchase the best glasses. I have seen them tested at the Royal Microscopical Society with the most costly objectives, where their performance has elicited the highest praise. When I state that an immersion $\frac{1}{16}$ costs in London but £3 10*s.*, the price of the low powers can be calculated.

These $\frac{1}{16}$ths have wonderful definition, and can be used upon all slides, having the ordinary thin glass cover, a great advantage. Such a glass could be sold here for thirty dollars, and the 1-inch and ½-inch for about ten dollars apiece. Except for special work, these objectives answer every purpose. The sketch at Fig. 1 is a correct drawing of the complete instrument, in position for use; and at Fig. 2, the same folded, showing its convenience and portability. The whole weighs about a pound, and can be carried, with eye-piece and object-glass ready for use, either in a bag or a light box 14 × 3½ × 3 inches.

Those who possess very large instruments will find this model a most useful addition for occasional use when traveling or demonstrating subjects away from home.

This form of microscope is offered as convenient for beginners, who, unable to purchase a complete instrument, still wish to make a beginning and start upon a right principle. Although a complete microscope can be purchased for about the same amount that the optical portions of this will cost, it will be wanting in the chief essentials of a good working instrument. Diminutive size, smallness of field, poor light, shortness of tube, absence of Society's screw, and other evils, will soon cause it to be cast aside, resulting in the loss of the original outlay; whereas the parts purchased under the above directions are portions of a first-class instrument, obtained in advance, which will never become obsolete.

The immense field of inquiry within the grasp of the microscopist is apt to disconcert and confuse the student. His course, however, should be well defined. First let him familiarize himself with what has been done by others, and then confine his attention strictly to those subjects which have reference to his profession or pursuit. If he has no special occupation, I would advise him to select a particular line of study, and let that be the thread on which to string his subsidiary matter, mounting his own objects, and carefully registering his observations. He will thus slowly but surely accumulate knowledge that will benefit the cause of science.

IS ALCOHOL A FOOD?

CORN and wine were deemed indispensable to man from the remotest antiquity, just as beef and beer are so considered by the Briton; and scarcely a people has existed who did not possess a fermented liquor of some kind—all ascribing to it exalted virtue, such as befits the gift of the gods, as all believed it to be—not only from the bodily comfort and invigoration which it imparted, but also from its mysterious effects in the transient madness which it is capable of producing. Among all nations, consequently, wine, or alcoholic drinks of some sort, has always had its poets or its minstrels; and, had the ancients been acquainted with alcohol, or the essential product of fermentation as *we* know it, doubtless they would have made it the symbol of the soul, for which nothing could be more appropriate; for it is an *invisible power*, hidden in a grosser body, which it influences in every part, and from which it finally escapes into the "heaven above"—gone forever! Nor is that all. The analogy may be extended to the *qualities* of that image of the soul, which are good and bad united, as in other mystic unions. Had the ancients possessed this knowledge of the distinct yet intimately combining principle, it might have given more significance to their devotion when they poured libations to their gods—but how much greater would have been their sense of awe and wonder, had they known what the physiologist knows at the present day! Let us glance at this truly mysterious agent in action.

Alcohol is ever ready to enter the animal system. It can be introduced under the skin or into a vein. Exalted by heat into the form of vapor, it may be inhaled by man or other animal, when it will penetrate into the lungs, will diffuse itself through the bronchial tubes, will pass into the minute air-vesicles of the lungs, will travel through the minute circulation with the blood that is going over the air-vesicles to the heart, will condense in that blood, will go direct to the left side of the heart, thence into the arterial canals, and so throughout the entire body.

Again, when taken in by the more ordinary channel, the stomach, it finds its way by two routes into the circulation. A certain portion of it—the greater portion of it—is absorbed direct by the veins of the alimentary surface, finds its way straight into the larger veins, which lead up to the heart, and onward with the course of the blood. Another portion is picked up by small structures proceeding from below the mucous surface of the stomach, and from which originate a series of fine tubes that reach at last the lower portion of a common tube, termed the thoracic duct—a tube which ascends in front of the spinal column, and terminates at the junction of two large veins on the left side of the body, at a point where the venous blood, returning from the left arm, joins with the returning blood from the left side of the head on its way to the heart. It is so greedy for water that it will pick it up from all the watery textures of the body, and deprive them of it, until, by its saturation, it can take up no more, its power of reception being exhausted; after which it diffuses itself into the current of circulating fluid. When we dilute alcohol with water before drinking it, we quicken its absorption; and, if we do not dilute it sufficiently, it is diluted in the stomach by the transudation of water in the stomach, until the required reduction for its absorption is effected.

Now, after an investigation of a very elaborate character, Dr. Anstie and Drs. Thudichum and Dupré have satisfactorily proved that only a very small portion of the spirit which is taken into a living body is expelled out of that body as alcohol, in the secretions, and that there must be some other means by which the spirit is disposed of in the system. In one very remarkable and memorable experiment, Dr. Anstie gave a dog, weighing ten pounds, the liberal dose of two thousand grains of alcohol in ten days, and, on the last day of the ten, he administered ninety-five grains of the spirit as a final dose, and then two hours afterward killed the dog, and immediately subjected the whole body—blood, secretion, flesh, membranes, brain and bone—to rigorous analysis, and he found in the whole texture of the body only about 23½ grains of spirit. The other 1,976 grains had clearly, therefore, been turned into something else, within the living system.

These experiments directly refer to our query—the settlement of the food-power of alcohol as a doctrine of physiological science.

Before reasoning out this proposition, we must state certain facts which it seems impossible to reconcile with any other theory than that alcohol is a food. Dr. Anstie relates the case of an old soldier who was under his care at the Westminster Hospital in 1861, who had lived for twenty years upon a diet composed of a bottle of unsweetened gin and "one small finger-length of toasted bread" per day and who maintained the structures of his body for this long period upon that very remarkable regimen. Similarly an old Roman soldier admired by the Emperor Augustus, when asked how he managed to keep up such a splendid development, replied—*Intùs vino, extùs oleo*—"With wine within, and oil without."

Dr. Robert D'Lalor tells us that some thirty years ago, in foreign climes and in unhealthy districts, he lived for two years upon wine and brandy, with very little solid food; and at the end of the period was neither perceptibly poisoned, starved, nor emaciated. Laborers, navvies, coal-heavers, and others, who take no beer, eat nearly as much again as those who take a moderate allowance of beer. Dr. D'Lalor declares that he knows many vigorous and healthy men in London, not only waiters, potmen, publicans, and the like, but tradesmen and merchants, who eat but little solid food, but have plenty of wine, porter, gin, etc.

Liebig stated that, in temperance families where beer was withheld and money given in compensation, it was soon found that the monthly consumption of bread was so strikingly increased that the beer was twice paid for—once in money, and a second time in bread. He also reported the experience of the landlord of the Hôtel de Russie, at Frankfort, during the Peace Congress; the members of the Congress were mostly teetotalers, and a regular deficiency was observed every day in certain dishes, especially in farinaceous dishes, pudding, etc. So unheard of a deficiency, in an establishment where for years the amount of dishes for a given number of persons had so well been known, excited the landlord's astonishment. It was found that the men made up in pudding what they neglected in wine. Finally, every one knows how little the drunkard eats.

Again, in cases of disease, there are numerous instances which it is difficult to refer to any thing but the food-property of alcohol. Dr. Anstie refers to one very instructive case of the kind, which also came under his care in 1861, and which obviously left a great impression upon his mind. A young man, only eighteen years of age, was so reduced by a severe attack of acute rheumatism, that he was unable to retain food of any kind upon his stomach. He was sustained for several days upon an allowance of twelve ounces of water and twelve ounces (¾ pint) of gin per day. His recovery under this treatment was very rapid and complete, and almost without any trace of the emaciation and wasting that ordinarily follow upon such a disease. The lad, previous to this illness, was of a strictly sober and temperate habit, and, during the use of gin, the abnormal frequency of the pulse and of the breathing came gradually down to the proper standard of ordinary health; and there was never at any time the slightest tendency to *intoxication*—which is a very notable point in such cases.

Dr. D'Lalor, before quoted, also mentions the case of a child only fourteen months old, suffering from inflammation of the lungs, and whose stomach could retain nothing but port wine. For twelve days it subsisted entirely upon wine; it was rapidly cured, with no wasting of any account; nor, although it drank large quantities of alcohol, was it ever intoxicated.

These cases are very important on account of their exceptional character; but they are quite in accordance with the well-established power of brandy and wine to sustain the life of sinking men in the critical periods of exhausting fevers; and they afford ground for the familiar and popular belief that there is support in wine and spirituous drink—as held of old and exemplified in the well-known recommendation of St. Paul to his ailing disciple.

Dr. Anstie's conclusion from such evidence, and from a very large hospital experience, is that, beyond all possibility of doubt, pure alcohol, with the addition of only a small quantity of water, will prolong life greatly beyond the period at which it would cease if no nourishment is given; that, during the progress of acute diseases, it very commonly supports not only life, but also the bulk of the body, during many days of abstinence from common foods; and that, although the physician and physiologist fail to explain chemically how it is that the result is brought about, it may, nevertheless, be safely affirmed that the influence exerted over the body by alcohol is, essentially, of a *food-character*.

"It may be well," observes a writer in the *Edinburgh Review*, "for even advanced and accomplished physiologists to bear in mind that there may be 'more things in heaven and earth than are dreamt of in their philosophy.' There would at least be nothing more startling in the discovery that the physiological dogma which affirms that the products of the reduction of complex organic substances (such as alcohol) cannot be employed as the food of animal life had to be *reconsidered*, and in some particulars reversed, or revised, than there has been in the recent reversal of the Liebig dogma, that *nitrogenous* principles alone can be used for constructive purposes, and the simpler hydrocarbons alone for the production of animal warmth."

And, in this point of view, Dr. Anstie argues that many substances which are ranked as even "poisonous" to the system must not be taken to be absolutely "foreign" to the organism, except in a relative sense, when even such agents as mercury and arsenic, given in small doses for long periods, produce what is termed a tonic influence, improving the quality of the blood and the tissues, and do this in such a way that it is scarcely possible to maintain that they contract no organic combination.

Dr. Anstie frequently dwells on the notable fact that in all cases of disease where alcohol is used successfully as a medicinal support—as in the case of exhaustive fevers—its presence as an alcoholic emanation, whether in the breath or in other secretions, is absent altogether, as if, in those cases, the whole force of the agent was absorbed in its beneficent operation. He also declares that in such instances its exciting and intoxicating powers appear to be in abeyance, and that the recovery from acute disease where this medicine has been successfully employed is invariably more rapid and complete than it is in altogether similar cases which have been treated without alcohol.

If alcohol be *only* a heat-producing food, it may be remarked that nowadays Liebig's well-known theory is no longer absolute, since it is established that great labor may be performed for a short period without the use of a nitrogenous diet—that is, with one exclusively carbonaceous. Hence, perhaps, the claim of alcohol to constitute a food. Although forming none of the constituents of blood, alcohol limits the combination of those constituents, and in this way it is equivalent to so much blood. As Moleschott says: "He who has little can give but little, if he wish to retain as much as one who is prodigal of his wealth. Alcohol is the *savings-bank of the tissues.* He who eats little, and drinks alcohol in moderation, retains as much in his blood and tissues as he who eats more, and drinks no alcohol."

But, while we thus know that alcohol supplies the place of a certain quantity of food, we do not know how it does so. It is said to be "burnt" in the body, and to make its exit as carbonic acid and water; but no proof has yet been offered of this assertion. Some of it escapes in the breath, and in certain of the secretions; but how much escapes in this way, and what becomes of what remains—in the very large proportion, in the case of the dog previously mentioned—is at present a mystery.

In Steinmetz's "History of Tobacco," p. 97, occurs the following surmise, published nearly twenty years ago, but now established as a matter of fact. He says: "I feel compelled to believe, in advance of Liebig, that *alcohol is absolutely generated in the digestive process of all animals.* Startling as the theory may seem, the consideration of corroborating facts may, perhaps, induce the reader to think it probable, if not certain. It is well known that all the vegetables we eat contain starch; all the fruits contain sugar. Now, starch can easily be converted into sugar; the process of malting is a familiar instance. . . . The natural heat of the body is precisely adapted, in the healthy state, to effect a fermentation after having changed the starch into *sugar*, which last is constantly found in the blood. That alcohol has not been found seems to result simply from the fact that it must be sought in arterial blood, or blood which has not lost a portion of its carbon *in transitu*, through the lungs in the respiratory process."

Now, it happens that Dr. Dupré, in the course of his investigations, discovered that alcohol is found in small quantity in the excretions even of persons who do not touch fermented beverage in any form—that is, the healthy system of the teetotaller *brews, so to speak, a little drop for itself.* But, if this be the case, it would seem that we have enough already in the system, and therefore there can be no need of having recourse to the bottle or the tap for more, unless the system be a prey to disease. And this applies especially to those who live mostly on vegetable or farinaceous food, who, it may be remarked, are naturally less inclined to alcoholic drinks than those who use animal food—when it becomes particularly dangerous. So that, if the Alliance and the supporters of the Permissive Bill would succeed in their aim, they should convert us all into vegetarians. To drunkards who are anxious to reform, this is a most important consideration.

In conclusion, the most reliable opinion respecting alcoholic drinks appears to be, that the relation of their actions to food is such that, when *they are required* by the system, they cause a necessity for increased food; but, when not required, they lessen the necessity for food. Now, as Dr. Edward Smith emphatically remarks, the tendency of *all* food, but particularly of animal food, is precisely in the same direction; so that the skin is drier after than before dinner, other things being equal. In like manner, the hands and feet, and the skin generally, become hot and dry after taking alcoholic drinks, and an intoxicated man in a state of perspiration would be an unheard-of phenomenon.

The direct tendency of alcohol is to diminish muscular power in a state of health, but indirectly it may have the contrary effect by improving the tone of the system through the appetite and digestion of food. In the state of body in which alcohol has reduced muscular contractibility, all the vital actions temporarily languish; and so far the action of alcohol is opposed to foods, and it is not a food.

While the food-action of beer and wine may be accounted for by their known nutritive ingredients, other than alcohol, which they contain, much difference of opinion exists as to the true action of alcohol itself, and the problem to be solved is, whether it acts physically or chemically. The known actions of alcohol in man are physical in their character, and so they are upon food immersed in alcohol, or alcohol-and-water, when it is hardened, and the process of digestion retarded.

If it has been shown that alcohol is capable of supporting a few persons, it is certain that it kills in its own way ten thousand persons a year in Russia, and fifty thousand in England; but its method of killing is slow, indirect, and by painful disease.

Finally, two things must always be borne in mind. First, we use alcohol not on account of its importance as a nutriment, but on account of its effects as a stimulant or relish; and secondly, the border-line between its use and abuse is so hard to be defined that it becomes a dangerous instrument even in the hands of the strong and wise, a murderous instrument in the hands of the foolish and weak.—*Food and Fuel Reformer.*

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SKETCH OF DR. H. C. BASTIAN.

PROMINENT among the contemporaneous explorers of biological and physiological science, the investigation of which is so active in the present age, is the subject of this notice, who, though still a young man, has achieved an undoubted eminence in the departments of study to which he has devoted himself. Dr. Bastian has done a good deal of excellent scientific work in the medical field, and has gained the wide respect of the profession; but he is more generally known by his researches into the origin of life; and is the author of perhaps the ablest work that has yet appeared on the question of the generation of the lowest animate forms. The careful readers of THE POPULAR SCIENCE MONTHLY are quite aware that the subject of so-called "spontaneous generation" has latterly not only occupied the increasing attention of scientific men, but has been pushed forward by an unprecedented refinement of experimental investigation. The researches recently carried out may have settled it, or they may not, as further determinations and verifications will show; but, whatever may be the fact on this point, the inquiry has certainly been remarkably narrowed, and the whole subject placed in a new attitude, which gives better promise of a decisive solution. Dr. Bastian, as is well understood, is a leading representative of the doctrine of the spontaneous origin of the lowest living forms. He has made an extensive series of delicate and ingenious experiments which, he holds, establish the principle, and which are freely admitted to give the problem a new aspect; and in his elaborate two-volumed work on the "Beginnings of Life," and his subsequent volume on "Evolution and the Origin of Life," he has given us the most comprehensive exposition we have of the philosophy and present position of this highly interesting and important question.

HENRY CHARLTON BASTIAN was born at Truro, in Cornwall, April 26, 1837. His father, a merchant, died while the son was quite young. He was educated at a private school in Falmouth; and, when about eighteen years of age, began the study of medicine with an uncle, who was a leading medical man of the town of Falmouth.

Young Bastian had already begun to acquire strong tastes for natural-history studies, principally in the direction of botany and marine zoölogy; these tastes having been much stimulated and encouraged by a retired London surgeon, Mr. W. P. Cocks, who had for some years energetically devoted himself to the fauna and flora of Falmouth and its neighborhood. Dr. Bastian recognizes a profound indebtedness to this gentleman for his influence in urging him to independent inquiry, inciting him to accept nothing on mere authority. During the three years of young Bastian's apprenticeship to his uncle, besides preparing for the matriculation examination of the University of London, he made a special study of botany, and in 1856 published "A Flora of Falmouth and Surrounding Parishes." His educational career was brilliant, and among the numerous university honors which he received may be mentioned the gold medal in botany; the gold medal in comparative anatomy; the gold medal in anatomy and physiology; the gold medal in pathological anatomy; and the gold medal in medical jurisprudence. He took his degree of M. D. in 1866, and became Fellow of the Royal Society in 1868. In 1860, Dr. Bastian became Assistant Curator of the Museum of Anatomy and Pathology under Prof. Sharpey. This office was retained for three years. In 1863, principally on account of his liking for cerebral physiology and philosophical subjects generally, he decided to devote himself to the study of insanity, with the view of becoming a consultant in London in this department of medicine. At the end of 1863 he went as assistant medical officer to the newly-opened State

Asylum for Criminal Lunatics at Broadmoor; and here for two years he carried on his investigations concerning the nematoids, which led to a monograph, in which one hundred new species were described. During this time and afterward, Dr. Bastian conducted an interesting and important series of investigations on the specific gravity of the brain. In 1866 he left Broadmoor, came to London, married, became lecturer on pathology and curator of the museum at St. Mary's Hospital Medical School. He now took up the study of the diseases of the nervous system as a whole, rather than the section of it met with in asylums. He was elected Assistant Physician to St. Mary's Hospital, and then shortly left it to accept the professorship of Pathological Anatomy and the position of Assistant Physician to the Hospital of University College. The same year he was also appointed Assistant Physician to the National Hospital for the Paralyzed and Epileptic. He has thus been in the midst of active and pressing professional studies, but Dr. Bastian has still found time for those laborious and purely scientific inquiries for which he is most extensively known. The following is a list of his chief memoirs and works, in the order of their publication:

"On the Structure and Nature of the Dracunculus or Guinea-Worm." "Trans. of Linn. Soc.," vol. xxiv.

"Monograph on the Anguillulidæ, or Free Nematoids, Marine, Land, and Freshwater; with Descriptions of 100 New Species." "Trans. of Linn. Soc.," vol. xxv.

"On the Anatomy and Physiology of the Nematoids, Parasitic and Free; with Observations on their Zoölogical Position and Affinities to the Echinoderms." "Philosophical Transactions," 1866.

"On the Mode of Origin of Secondary Cancerous Growths." *Medical Mirror*, vol. i., No. x.

"On the Specific Gravity of the Different Parts of the Human Brain." *Journal of Mental Science*, January, 1866.

"On the so-called Pacchionian Bodies." "Trans. of the Microsc. Soc.," July, 1866.

"On the Pathology of Tubercular Meningitis." *Edinburgh Journal of Medical Science*, April, 1867.

"On a Case of Concussion-Lesion of the Spinal Cord, with Extensive Ascending and Descending Secondary Degenerations." "Trans. of Medico-Chir. Soc.," 1867.

"On Cirrhosis of the Lungs." "Reynolds's System of Medicine," vol. iii.

Also the sections on "Pathology and Morbid Anatomy" of the following joint articles (by Dr. Reynolds and Dr. Bastian) appeared in "System of Medicine," vol. ii.: "Cerebritis;" "Non-Inflammatory Softening of the Brain;" "Congestion of the Brain;" "Hypertrophy of the Brain;" "Adventitious Products in the Brain."

"Modes of Origin of Lowest Organisms." *Macmillan*, May, 1871.

"The Beginnings of Life," 2 vols., Appletons, 1872.

"Evolution and the Origin of Life," Macmillan, 1874.

"On Paralysis from Brain-Disease in its Common Forms," Appletons, 1875.

CORRESPONDENCE.

A CORRECTION.

To the Editor of The Popular Science Monthly.

SIR: Please allow me to correct some errors in the notice (on page 760 of this journal for October) of the paper on "American Ganoids," read at the Detroit meeting of the American Association for the Advancement of Science.

The *very* young gar-pike (*Lepidosteus*), less than an inch long, has only *one* tail; a symmetrical organ like that of existing *Amphioxus* and *Polypterus*, and the fossil *Glyptolæmus*.

While from one to ten inches long, the growing gar manifests a *lower lobe of the caudal*. In this state it resembles the existing sturgeons and sharks, and many fossil Ganoids.

The filamentary original tail gradually decreases and finally disappears, while the lower lobe increases and becomes the functional tail of the adult *Lepidosteus* and *Amia*. In this respect, therefore, these forms are *modern* types of an ancient group.

In describing the peculiar vibratory movement of the caudal filament of the young gar, I compared it to the rapid vibration of the tail in many if not all serpents, and notably in the rattlesnake, and suggested that, in view of the ball-and-socket articulations of the vertebræ of *Lepidosteus* and some other reptilian features, the resemblance between the motions of *Lepidosteus* and *Crotalus* may have a deeper origin and significance than mere functional similarity; that they may have had a common ancestry not very remote. But I had no idea that "the ancestor of the gar was a reptile."

This correction seems to me the more desirable, since the other paper noticed by you (on the *Sirenia*) was chiefly to show that a retrograde metamorphosis had taken place with that group.

BURT G. WILDER.

ITHACA, N. Y., *September 27*, 1875.

FORESTS AND RAINFALL.

To the Editor of the Popular Science Monthly.

WHILE recently traveling among the mountains of this State, the threatening approach of a storm obliged me to find a shelter, whence my attention busied itself in watching the clouds gathering upon the slopes that reached at least two thousand feet above the valleys.

Some portions of them, I observed, became quickly covered; others more slowly. In due time the storm broke away, and, relieved partially of their watery burdens, the clouds commenced to lift and move off, but some more tardily than others. Moreover, I remarked that, where they had first collected, there they remained the longest, and that those parts of the acclivities concealed the last were the first to become visible.

Such a singular coincidence led me on further to the consideration of its cause. I think it may be extracted from the following facts: 1. The day had been very warm, as had also been the weather for a week before. 2. Of those portions of the slopes that had become hidden, the timbered lands were the first and, as mentioned above, the last to be seen again; the contrary happening to the rock-exposures. 3. The valley in which I was is formed by mountains over four thousand feet above sea-level, their opposing acclivities being very near to each other. It is therefore narrow, and it was shielded from the cooling influences of winds outside. 4. The radiation of heat from the bare sides and precipices.

Generalizing the conclusions that may be drawn from these, it may be said that sometimes clouds passing over barren surfaces, like some of those I had been viewing, will become lightened as the cohesion of their particles is weakened by the warmer ascending currents of air; they may be dispersed, and, even if they settle down, will be more likely to rise again before those covering forests.

With the latter it will be otherwise. Every leaf, like a miniature sun-shade, protects a part, small though it be, of the soil from the direct warmth of the sun. Forests thus are like great canopies sheltering from the sun's rays those sections upon which they grow. Lands so covered possess a capacity for holding much moisture. Contained in the leaves and trunks of trees, and more particularly in the spongy moss and numerous streams, it is saved from rapid evaporation, and consequently lowers the temperature of the atmosphere over it.

Vapors, then, attracted toward mountains by gravity, or carried thither by winds, will at times collect first over those sections which are wooded, and will have a tendency to remain there, be condensed, and deposit rain.

It may not be out of place to notice here another fact coming under my observation. Winds sweeping across a country, when they encounter mountains, are crowded against them, and, by the pressure from behind, are forced up along their sides and over their crests. Clouds that are in their paths, and which are borne onward to the slopes of such mountains, are sometimes carried up to and over their tops. Slopes which are destitute of timber present very few obstacles to such a result. Forests, on the other hand, break or lessen the mechanical strength of wind, and so increase the probability of their augmenting the volume of rainfall. P. F. SCHOFIELD.

NEW YORK, *September*, 1875.

EDITOR'S TABLE.

WHICH UNIVERSE SHALL WE STUDY?

A CERTAIN class of astronomers have aimed to persuade us that there are "more worlds than one;" and those ingenious speculators Stewart and Tait have recently argued for two universes: the present universe, open to the sense, and an "unseen universe" beyond the range of direct scientific investigation but open to intrepid scientific faith. From another point of view this idea of two universes comes out in a much more definite and practical way; and that is when considered with reference to the two great orders of knowledge that are now making rival claims on the attention of mankind as means of education. This conception of two universes as objects of thought was very instructively set forth by the able author of the articles we have published under the title of "The Deeper Harmonies of Science and Religion," in his third paper, and the passage defining the distinction is so well drawn that it will bear repetition. The writer says:

"There is something which sets itself up as a just reflection of the universe, and which it is possible to study as if it were the universe itself; that is, the multitude of traditional unscientific opinions about the universe. These opinions are, in one sense, part of the universe; to study them from the historic point of view is to study the universe; but when they are assumed as an accurate reflection of it so as to divert attention from the original, as they are by all the votaries of authority or tradition, then they may be regarded as a spurious universe outside and apart from the real one, and such students of opinion may be said to study, and yet not to study the universe.

"This spurious universe is almost as great as the genuine one. There are many profoundly learned men whose whole learning relates to it and has no concern whatever with reality. The simplest peasant, who, from living much in the open air, has found for himself, unconsciously, some rules to guide him in divining the weather, knows something about the real universe; but an indefatigable student, who has stored a prodigious memory with what the schoolmen have thought, what the philosophers have thought, what the fathers have thought, may yet have no real knowledge; he may have been busy only with the reflected universe. Not that the thoughts of dead thinkers stored up in books are not part of the universe as well as wind and rain; not that they may not repay study quite as well; they are deposits of the human mind, and by studying them much may be discovered about the human mind, the ways of its operation, the stages of its development. Nor yet that the thoughts of the dead may not be of the greatest help to one who is studying the universe: he may get from them suggestions, theories, which he may put to the test, and thus convert, in some cases, into real knowledge. But there is a third way in which he may treat them which makes books the very antithesis to reality, and the knowledge of books the knowledge of a spurious universe. This is when he contents himself with storing their contents in his mind, and does not attempt to put them to any test, whether from superstitious reverence or from an excessive pleasure in mere language. He may show wonderful ability in thus assimilating books, wonderful retentiveness, wonderful accuracy, wonderful acuteness; nay, if he clearly understands that he is only dealing with opinions, he may do good service in that department, for opinions need collecting and classifying as much as botanical specimens. But one often sees such collectors mistaking opinions for truths, and depending for their views of the universe entirely upon these opinions, which they accept implicitly without testing them. Such men may be said to study, but not to study the universe."

This discrimination is both true and highly significant. Old opinions, old languages, and antiquated learning, are fit subjects of study as a part of archæology, like old buildings, old costumes, old coins, ear-rings, pictures, etc., which are not without a certain historic interest. But from this point of view they are parts of the universe to be explored and explained, like all the rest of it, by scientific methods. This, however, is a widely different thing from setting up old knowledges and thoughts of the dead as systematic and exclusive objects of study, and the sufficient means of mental cultivation. Yet the advocates of education by traditional, unscientific studies habitually slur over this distinction, and, declaring that old languages and old traditional ideas are as much parts of the universe as the rocks and stars, proceed to install them into a separate world in which the great multitude of students are made to pass their whole intellectual lives. It is no exaggeration or mere figure of speech to characterize this realm of antiquated thought and dead language as a spurious universe. No one will deny that the broad and distinctive object of scientific study is the real and present universe of phenomena, fact, and law, which is open to the direct, immediate action of the human mind. The study of it in all its phases, by observation, experiment, analysis, synthesis, and classification, has given rise to a vast body of truths and principles known as scientific knowledge, or modern scientific thought, and by which and through which the actual living universe is to be interpreted and known. Obviously the keys to the knowledge of the real universe are held by science, and it is inevitable that, if scientific knowledge be left out of any educational scheme, the genuine universe is omitted from that scheme. And when this subtraction has been accomplished what remains? An unreal sham, an illusive, discordant representation of things which may now be justly termed a "spurious universe." We say it may *now* be justly so termed, although, before the true universe was discovered, there could have been no knowledge of its counterfeit. The mass of pre-scientific opinion concerning the world and its contents, the course of Nature, man, life, and society, when taken in relation to what is now known of these subjects, and when regarded as a body of thought to be employed for purposes of culture, must be held as representing not the universe of reality, but only a distorted and spurious semblance of it.

The question of scientific education, then, undoubtedly the greatest question of our time, is simply this: "Shall we study the genuine or the spurious universe? Shall the minds of students be developed and moulded by direct exercise upon the phenomena and problems of Nature and present human experience, or shall they be cut off from the living world and trained in the acquisition of old knowledges, just as if science had never arisen?" This question may seem to many a futile one, as they will say that in this age the influence of science cannot be escaped. Nevertheless it is an urgent and a practical question. For, although the influence of science cannot be escaped by society, it can be and it is extensively evaded and escaped in education. In this our schools and colleges do not represent the age; they are out of harmony with it; they are far behind it. The genuine universe is not the supreme object of study; it is only partially recognized or not recognized at all. The spurious universe is still in the saddle. It has not been displaced; it has hardly been disturbed. Science is still begging of our colleges for a few crumbs; and, when snubbed, is trying here and there to organize schools of its own, which are generally looked upon as mere technological shops where needy youths are apprenticed to bread-and-butter occupations a grade or two above the workshops of artisans and mechanics. The dignity of being liberally educated, the honors of scholarship, and the prestige of culture, are reserved for those who, passing by all the grand results of modern science, give themselves to the study of the spurious universe.

The latest illustration that comes to us of the extent to which this statement is true, is furnished by the condition of the great public or preparatory schools of England. An official report has been made upon this subject, which represents the state of things after a quarter of a century of vehement agitation for some reformatory change that shall bring the popular culture of that country into greater harmony with the present state of knowledge. The case is thus forcibly presented by the London *Spectator*, a journal that will not be suspected of extreme views upon the subject:

"During the past three hundred years, the spread of scientific knowledge has revolutionized European modes of thought, has fundamentally altered the European idea of the universe, of the earth's place in the grand whole, and of man's place on the earth, and has profoundly modified European social life and political institutions; but, to our great schools, science has been as if it had made no progress. To those who have regulated the studies of those places of learning, it has not appeared at all important that English gentlemen should be able to follow with intelligence the fruitful researches to which the pioneers of modern thought were devoting themselves, should be capable of appreciating the discoveries which were abridging space, approximating classes, and calling into existence industries, activities, and relations, that are gradually transforming the ancient order of things—in a word, that they should be in sympathy with the modern spirit. . . . Of course, such a state of things has not been allowed to continue without protest and controversy, and some little has been done to make room for science-teaching in our schools. It has, however, been very little. The sixth report of the Royal Commission on scientific instruction now lies before us. It is confined exclusively to an examination into the provision made in the various secondary schools throughout the country for the teaching of science, and this is what appears: Returns, more or less complete, were received from one hundred and twenty-eight endowed schools in all, and, out of this total, 'science is taught in only sixty-three, and of these only thirteen have a laboratory, and only eighteen apparatus, often very scanty.' Even these figures, however, give but a very imperfect notion of the neglect with which science is treated. It will hardly be believed that there are no more than eighteen of these schools which devote as much as four hours in the week to scientific instruction, that sixteen actually afford no longer time than two hours a week, and seven think an hour sufficient. These, however, are the good examples. There are thirty schools in which no definite time whatever is allotted to scientific study. Again, out of the one hundred and twenty-eight schools, only thirteen give any place at all to science in their examinations, and 'only two attach a weight to science in the examinations equal to that of classics or mathematics.'

"If, now, we attempt to account for this extraordinary neglect of science, in a country whose greatness, if not its very independence, depends upon the skill of its population in using the forces of Nature as their servants, we find the blame to rest in a very great measure on the universities. The older universities were founded and attained celebrity at a time when natural science did not exist, and they have never admitted science to an equality with classics and mathematics. The feeling of Oxford and Cambridge has naturally guided the public schools. The masters are, almost without exception, even to-day, Oxford and Cambridge men, and are penetrated with the Oxford and Cambridge spirit. Moreover, the parents of the boys, and the boys themselves, necessarily attach importance to the studies which will win honors and distinction at the universities, while they disregard studies that will in no way help them in their careers. Lastly, the neglect of science at the universities causes the schools to suffer from a want of competent teachers. Most of the head-masters in their evidence refer to this difficulty, but, at the same time, they are unwilling to look elsewhere for the kind of men they want. Thus the head-master of Rugby says: 'I would here observe that a mere chemist, geologist, or naturalist, however eminent in his own special department, would hardly be able to take his place in a body of masters composed of university men, without some injurious effect upon the position which science ought to occupy in the school. . . . In preferring the two older universities, I do so only by reason of their stronger general sympathies with public-school teaching. I am aware that if I merely wanted a highly-scientific man in any branch, I might find him equally in Dublin, London, or at a Scotch university.' In plain language, trades-unionism forbids an ugly competition."

It thus appears that the policy of one hundred and twenty-eight of the leading schools of England, in regard to the admission of scientific studies, is powerfully influenced, if not controlled, by the universities, so that, in the foremost nation in the world, there is a vast, compactly-organized educational system which ignores the universe, as disclosed by modern science, and employs as its means of mental cultivation a spurious universe of dead traditions, languages, methods, and opinions.

LITERARY NOTICES.

First Book of Zoölogy. By **Edward S. Morse**, Ph. D., late Professor of Comparative Anatomy and Zoölogy in Bowdoin College. New York: D. Appleton & Co. Pp. 188. Price, $1.25.

The genius for good school-book making is incontestably American. Our best school-books exemplify art in two directions: in that which goes to the getting up of the book, materially, and that which concerns its intellectual self; that is, its way of putting things—such a handling of teaching processes as recognizes that good teaching is an art, and the true teacher an artist. As good tools for teacher and learner, American school geographies, arithmetics, readers, and lately grammars, are not excelled abroad. It is noteworthy, however, that hitherto so much could not be said of American efforts in the matter of elementary school-books on science. Herein has England set us an example. The "Science Primers," reprinted by the Appletons, are very remarkable books as showing how a high knowledge in these departments may be set before a little child. However, in this matter of American science-teaching of the little ones, the tide is setting in. It must be admitted that in every thing pertaining to books, and elementary teaching of animated Nature, we are far behind England. Dr. Hooker's "Child's Book of Nature" is the best of its class, though sadly needing rewriting. But when we come to zoölogy proper, a history of our efforts at elementary book-making is more interesting than creditable. The earliest serious effort is that of Daniel Haskel—"The Juvenile Class-Book of Natural History," 1841. It is for children, and the author boasts in the following style over its systematic arrangement: "The classification, which forms an important feature of the work, is founded on external resemblance and visible habits. . . . This classification is much more simple, and better adapted to the young mind, than that of Linnæus, which is founded on occult resemblances, and ranks the cow and the whale, animals which inhabit different elements, and are otherwise very unlike, in the same general class, *Mammalia*." As to man, he says, "Buffon divides mankind into six classes," and he does likewise. But the word "class," though often used, has no certain sense in this little book. Leaving man, the work is divided into Quadrupeds, Birds, Fishes, Reptiles, and Insects. The quadrupeds are divided into thirteen classes, as first class, second class, etc. Then come the "Unclassed Animals," viz., "the elephant, rhinoceros, hippopotamus, tapir, camel, Arabian camel, llama, camelopard, bear, badger, raccoon, kangaroo, opossum, ant-eater, sloth, jerboa." He says these "are animals which cannot be classed, but each of which by itself forms a distinct species." The birds are given in like manner in six classes, with "unclassed birds, the ostrich, cassowary, dodo." The fishes are in four classes. The first class embraces the cachelot, grampus, porpoise, dolphin, whale." As for the sword-fish, he is left out in the cold. The "fourth class" of fishes embraces the lobster, crab, tortoise, oysters, snails, and such.

The next attempt at a natural history for schools was (we speak from memory) by Abram Ackerman. It was a mere compilation, with not a particle of science behind it or in it. It had the credit, however, of not being the injurious book that Haskel's was. In 1849 appeared "Class-Book of Zoölogy: designed to afford to Pupils in Common Schools and Academies a Knowledge of the Animal Kingdom. By Prof. B. Jaeger." The educational plane was not then up to this little book, which, as a classification, or systematic exhibit of the animal kingdom, had not its equal; and, besides this, much of it was really American, but zoölogy proper it utterly failed to teach. Prof. Worthington Hooker's "Natural History, for the Use of Schools and Families," appeared in 1860. It is a good book, and holds its own in the market because of its pleasant and readable style. As a classification it is too meagre, and of zoölogy it contains but little. We must not pass unmentioned the Ruschenberger series of "First Books in Natural History," begun in 1842. These were little else than translations from the text of Milne Edwards and Achille Comte. Very excellent little manuals they were, but extending, as they did, to eight volumes, they lost all claim to be called a "Primer of Natural History." "Principles of Zoölogy, by Agassiz and Gould," 1848, is a high text-book; and of a like nature must be regarded "A Manual of Zoölogy," by Sanborn Tenney, 1865, with its smaller companion by the same author; both good books so far as systematizing goes.

It is evident, then, that a good, true American book, worthy of being called a "Primer of Zoölogy," had not appeared. In the fullness of belief, we avow our conviction that it has come at last. We do not allude to Mrs. Stevenson's "Biology for Boys and Girls;" it occupies a widely-different field. "First Book of Zoölogy," by Prof. Morse, is the little work which we wish to consider. It has some points on which we would for a moment dwell. First, it really teaches zoölogy. It deals with the morphology and actual structure of familiar things. It advises you to get snails or insects, and shows how to get them. Now, every one should know that this is just what a child wants to do. Every child is naturally a collector. Then comes the study of form. Here are simple outline drawings. The external parts are laid out, and each part is shown to the pupil, and its name as a part is given. Now the child must draw these parts on his slate, and then name them for himself; and every child with a little patient help can do all this. But, when this is done, the morphology of a shell, or whatever else, is well learned, albeit the little pupil has never heard the big word used above. And what an eye-opener, and mind-expander, and tongue-loosener, half an hour of such work with a child is! The little child becomes at once a naturalist, intent upon his snail, he sees things, and thinks things, and asks things, that are all new to him. This little book utterly eschews technicalities, and even classification. An intelligent boy will make a collection, and then will attempt to sort it into groups or sets of real or fancied similitudes. This is instinctive classification. But it is plain that the collection must come first; that is, that intelligent classification must stand related to things more than words. A blind man could not classify the stars. Here, then, is the blunder which our author shuns: of beginning to teach systematic classification with no knowledge or sight of the objects. The author's method is that of Nature. It is the word-method in reading instead of the old A B C plan. Get your object, then learn its parts, and, thus trained, classification will be sought for, and can then be entered upon; and even its systematic names will be learned with delight, because they have a real significance; that, of course, will be the work of a "Second Book." The first is just such as any teacher can handle, and that too with pleasure, for it unfolds the objects of Nature precisely in Nature's own way. A real excellence in a primer is, that it is small. This little book reminds us of the pinhole in the card to which the eye is applied; it takes in a very little bit of Nature, but that bit is wonderfully amplified with good, clear, achromatic light. In this wise it is that one who has done a long service in teaching natural history to children hails Dr. Morse's little book. S. L.

Money, and the Mechanism of Exchange. By W. Stanley Jevons, F. R. S., Professor of Logic and Political Economy in the Owens College, Manchester. No. XVII. "International Scientific Series." New York: D. Appleton & Co. 350 pages. Price, $1.50.

There is, beyond question, a most important scientific side to the complex subject of money. It has its observable phenomena, its analyzable relations, and its deducible laws; and, as it pertains to the operations of human society, it is a legitimate branch of social science. For this reason it was entirely proper that the subject should be treated in an independent monograph in the "International Scientific Series." One of the ablest and clearest logical heads in Europe, author of a masterly treatise on the philosophy of science, and a special and thorough student of political economy, was chosen to execute the work. Again there were permanent, general, and what we may term cosmopolitan reasons for taking up the subject with a view simply to the exposition, improvement, and extension of valuable knowledge.

But for us the subject has also quite another aspect. There were urgent American reasons why it should be treated. We believe in the glorious leadership of our country; we are in advance, and bound to be in advance, of civilization, and in this case the American people furnish ample evidence that they are quite ahead of the world in their ignorance of every thing like principles or laws relating to money. The American voter, with his hands full of greenbacks, has about as much understanding of the science which treats of them as the Indian of the science of wampum. That they can buy things with them, and that they are therefore desirable to be got, exhaust the knowledge of both. With all our vaunted enlightenment, we have a currency bedeviled by politicians in the interest of selfish greed and rampant speculation, and maintained by a demagoguism as unscrupulous and vicious as the world has ever seen. With so much gross ignorance and stupid superstition among the people in regard to the nature of money, and the laws of its use and influence, that the present state of things is openly defended and its continuance demanded, it becomes in the highest degree desirable that sounder views should be disseminated as rapidly and as widely as possible. We want a knowledge of money as a branch of natural history. We want to know how its use has grown up; what wants it answers to in human societies; what laws it is subject to that spring from the very nature of things; what are its imperfections, and how they may be supplemented; what are its dangers, and what the delusions and impostures of which it is made the means by calculating men and unprincipled governments. Prof. Jevons's work deals with the subject very much from this point of view. He offers us what a clear-sighted, cool-headed, scientific student has to say on the nature, properties, and natural laws of money, without regard to local interests or national bias. His work is popularly written, and every page is replete with solid instruction of a kind that is just now lamentably needed by multitudes of our people who are victimized by the grossest fallacies.

RELIGION AND SCIENCE IN THEIR RELATION TO PHILOSOPHY. By CHARLES W. SHIELDS, D.D. New York: Scribner, Armstrong & Co. Pp. 69. Price, $1.00.

THIS essay consists of two parts, in the first of which are stated the scientific hypotheses and the religious dogmas that have been offered for the solution of such problems as the origin of the universe, the formation of geological strata, the origin of man, the nature of mind and of matter. The case for both sides is stated fairly enough. In the second part the author endeavors to show that these problems are neither exclusively scientific nor exclusively religious, but philosophical. "It is not too much to say that they can never be decided by any merely scientific process. . . . And it is safe to say that by no purely religious method can they ever be settled." The author regards these problems as "partly scientific and partly religious," but "strictly philosophical." Hence philosophy is the umpire when religion and science are in conflict. "Paramount as religion must be in her own sphere with her inspired Bible and her illumined Church," she cannot judge the theories of science; but no more will religious men accept from mere scientists a judgment upon their doctrines. The author thinks that in the "broad plain of philosophy" the religionist should accept scientific truth resting upon "foundations of proof that cannot be shaken;" and that the scientist should no longer ignore "that vast body of truths, doctrines, dogmas, backed by evidences which have been accumulating for eighteen centuries under the most searching criticism." There appears to be no reason why men of science should reject the arbitration of philosophy.

PROCEEDINGS OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES; from May, 1874, to May, 1875. Selected from the Records. Boston: John Wilson & Son, 1875.

THIS is the second octavo volume of "Proceedings" of the "New Series," and the tenth of the "Whole Series" published by the American Academy; Volume I. having been published in 1848. Besides the octavo *Proceedings*, the Academy has long published quarto volumes of *Memoirs* which are of the highest value. This volume contains 535 pages, of which 462 are devoted to scientific papers, 13 to brief notes of the several stated meetings, 41 to the Report of the Council (into which are incorporated the obituaries of deceased members or associates), six pages to the list of the members, etc., and the rest of the volume to a very copious index.

We learn that the Academy contains 195 Fellows, 91 Associate Fellows, and 70 Foreign Honorary Members. The losses by death during 1874 have been painfully large, and many of them will not be felt by Massachusetts alone, but by the world at large. Short biographical notices are given of the following deceased members: B. R. Curtis, ex-Judge Supreme Court; George Derby, M. D., Professor, Harvard College; F. C. Lowell;

Charles G. Putnam, M. D.; Nathaniel B. Shurtleff; James Walker, ex-President Harvard College; Jeffries Wyman, Professor, Harvard College; F. W. A. Argelander, Professor, University of Bonn; Elie de Beaumont, Secretary Paris Academy of Sciences; Sir William Fairbairn, F. R. S., etc.; F. P. G. Guizot; Sir Charles Lyell.

Of the scientific papers given, ten are devoted to Chemistry and Physics, four to Botany, four to Astronomy and Astronomical Physics, two to pure Mathematics, etc. But such an enumeration does not convey any adequate idea of the amount of original research represented by this volume, which is in every way creditable to American science, and fully equal to similar publications in Europe. It is not possible within the limits of our space to attempt any analysis of individual papers, for a knowledge of which reference must be made to the volume itself; but it is impossible to avoid a renewed notice of the remarkable freshness of the volume as a whole. It bears the evidence of being the systematized results of faithful work in the laboratory, the field, and the study, and it has in this and in other respects an advantage not common to all American publications of the same kind.

American State Universities. With a Particular Account of the Rise and Development of the University of Michigan. By **Andrew Ten Brook.** 418 pages. Price, $3.50. Cincinnati: R. Clarke & Co.

The author of this work, in his first chapter, presents a sketch of the early progress of academic education in the Atlantic States. Next he describes the state of culture in the West at the beginning of the congressional land-grant policy and subsequently. The history of congressional land-grants for universities is given in the third chapter. The remainder of the book is more specially devoted to the subject of education in Michigan, and the matters treated in the successive chapters are: Michigan's early condition as to culture and education; early organization for higher education in that Territory; grant of the present university fund, and its administration by the board of trustees; organization of the school system and administration of the endowment fund; rise of union schools; opening of the Ann Arbor University; review of the period from 1844 to 1852; the administration of President Tappan; administration of President Haven and his successors. Finally, the author essays to forecast the future of American universities. He is in favor of retaining the study of ancient languages as the dominant feature, the very backbone of the university system. "The long-agitated question," he says, "of the place which the Latin and Greek languages should hold in education, the University of Michigan settled originally by giving them the same prominence which they had in the old colleges of this country, and the State universities generally have inclined to this course. This action needs no comment or defense beyond a statement of the reasons which have been supposed to justify it. The relation of the study of these languages to that of other subjects has been greatly changed by the introduction of new branches of study, but not by any special change of views in regard to the value of languages themselves." Science, according to Mr. Ten Brook, is of little or no importance except for specialists. "Language is of all studies the most practical. The useful and sublime sciences, such as chemistry, botany, geology, and astronomy, *are of little immediate use even to the learned.* Their main facts and generalizations are indeed well employed in literature, in philosophy, and in social life; *but beyond these they are only to be pursued by the special student.*" Again, he says: "It was the ancient classics, and the Hebrew and Greek Scriptures in their originals, which awakened Europe from the sleep of the middle ages. They are adapted to just that kind of work, and they will probably hold their place for ages to come, as for centuries past, in the course of higher education." Our own views on this question are fully stated in the leading editorial of the present number.

Annual Report of the Directors of the St. Louis Public Schools. Pp. 398.

Besides the usual statistics, the various annual reports contained in this volume convey a large amount of valuable information on school management in general. The idea of having attached to the Normal School a "School for Observation" appears to be original to the St. Louis system. This school for observation differs from the "Model School" in that the Normal scholars here simply observe the process of managing a school as conducted by highly-competent teachers, while in the Model School they make experiments in teaching. The school selected for observation is one of the district schools of the city. The members of the senior and middle classes of the Normal School are sent regularly to the "School for Observation" in order to acquire a more thorough knowledge of their future profession.

The experiment begun two years ago, of establishing a Kindergarten in connection with one of the public schools, has, according to the Report, proved a decided success. Like every effort toward new and improved methods in education, the project, at the outset, met with strong opposition. It was urged that children enough would not attend to justify the expense. The younger children of three and four could not be sufficiently interested; small children would not attend regularly; the training would unfit for ordinary primary work; the physical exercises would be injurious to health; and so on, to the end of the string of imaginary difficulties that objectors are forever ready to throw in the way. The result was that, when the school opened, the room was quickly filled. At the beginning of the second year nearly all the children of the previous year reëntered, and a second room of equal capacity was found necessary, and this also was filled. The average attendance was ninety-five per cent., exceeding that in the primary rooms. The children advanced to the primary department made rapid progress in its studies, excelling rather than falling behind their fellows. The physical exercise produced a marked improvement in the health and general appearance of the pupils; and, finally, it has been determined to establish Kindergartens in two more of the public schools.

This and other parts of the Report show what preceding reports from the same source had previously shown, that the authorities in St. Louis are alive to the necessity for improvement in our methods of primary instruction, and it would be well if school-officers in Eastern towns could be charged with a similar spirit. The streets of New York, for example, are swarming with children from three to six years old, receiving at the most impressible period of their lives the lessons that only the streets can teach. If, in place of these abominable associations, they were gathered into Kindergartens, the formation of habits that later become actual obstacles in education would be in great part prevented, while a positive advantage would be gained in the training which such schools afford.

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Reference and Dose Book. By C. Henri Leonard. 16mo, 80 pages. Price, 75 cents; and Vest Pocket Anatomist. By same. 16mo. Price, 50 cents. Detroit, 1875. Pp. 56.

The Origin of the Sun's Heat and the Chemical Constitution of the Matter of his System. By William Contie. Troy, 1875. Pp. 23.

Tinnitus Aurium. A Consideration of the Causes upon which it depends, and an Attempt to explain its Production in Accordance with Physical Principles. By Samuel Theobald, M. D. Baltimore: Innes & Co., Printers. 1875. Pp. 13.

Circulars of Information of the Bureau of Education. No. 6. Washington: Government Printing-Office, 1875. Pp. 208.

On the Flexure of Continuous Girders. By Mansfield Merriman, C. E. 1875. Pp. 12.

Printing for the Blind. Reply to the Report of a Committee of the American Social Science Association. By the Trustees of the American Printing-House for the Blind. Louisville, Ky., 1875. Pp. 16.

Have we Two Brains? Soul and Instinct, Spirit and Intellect. Address by Rector of St. Mary's Church, Station O, N. Y. 1875. Pp. 12. Price, 10 cents.

Alimentation of Infants and Young Children. By B. F. Dawson, M. D. New York: William Wood & Co. 1875. Pp. 22.

Catalogue of the Iowa State University for 1874–'75.

A Graphic Method for solving certain Algebraic Problems. By George L. Vose. New York: D. Van Nostrand. 1875. Pp. 62. Price, 50 cents.

Manual for the Use of the Globes. By Joseph Schedler. New York: E. Steiger. 1875. Pp. 34. Price, 25 cents.

Consciousness in Evolution. A Lecture delivered before the Franklin Institute, Philadelphia. By E. D. Cope, 1875. Pp. 16.

Our Teeth and their Preservation. By L. P. Meredith. Cincinnati, 1875. Pp. 43.

History of the Philadelphia School of Anatomy. By William W. Keen, M. D. Philadelphia: Lippincott & Co., 1875. Pp. 32.

Anatomical, Pathological, and Surgical Uses of Chloral. By same. 1875. Pp. 11.

Experiments on the Laryngeal Nerves and Muscles of Respiration in a Criminal executed by Hanging. By W. W. Keen, M. D. 1875. Pp. 8.

Matter and the Laws of Matter; and The Self-Existence of Matter inconsistent with the Existence of God. By William H. Williams. Each ten pages.

Iowa Weather Review, September, 1875. Edited and published by Dr. Gustavus Hinrichs, Iowa City, Iowa.

A Study of the Normal Movements of the Unimpregnated Uterus. By Ely Van De Warker, M. D. New York: D. Appleton & Co., 1875. Pp. 26.

On the Transcendental Curves whose Equation is, $\sin y \sin my = a \sin x \sin nx + b$. By H. A. Newton and A. W. Phillips. Reprinted from Transactions of Connecticut Academy.

A New Basis for Uterine Pathology. By A. F. A. King, M. D. New York: William Wood & Co., 1875. Pp. 20.

The Uranian and Neptunian Systems investigated with the 26-Inch Equatorial of the United States Naval Observatory. By Simon Newcomb. Washington, 1875. Pp. 74.

The Relation of the Patent Laws to American Agriculture, Arts, and Industries. Address by James A. Whitney before the New York Society of Practical Engineering. New York, 1875. Pp. 37.

Annual Report of the Superintendent of Public Instruction, on the Public Schools of New Hampshire. Concord, 1875.

Nature and Culture. By Harvey Rice. Boston: Lee & Shepard, 1875. Pp. 202. Price, $1.50.

A Manual of Metallurgy. By William H. Greenwood, F. C. S. New York: G. P. Putnam's Sons. Pp. 370. Price, $1.50.

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MISCELLANY.

We present below brief abstracts of some of the more interesting papers read at the last meeting of the British Association for the Advancement of Science. Others will follow in succeeding numbers.

Ice-Action.—The subject of ice-action was considered in a paper read by D. Mackintosh, F. G. S. He first discussed the question whether the so-called continental ice of Greenland was a true ice-sheet formed independently of mountains, or merely the result of a confluent system of glaciers. He then considered the state of the surface of the Greenland ice-sheet, and believed that the amount of moraine matter was locally limited and of small extent. He defended the idea of the internal purity of existing ice-sheets, and gave reasons for doubting whether glaciers are capable of persistently pushing forward the large stones they may find in their beds, though he admitted that the base of glaciers is charged with finer *débris*, by means of which they grind and striate rock-surfaces. He mentioned that in the lake district of England he had never seen a sharply-bordered groove on a glaciated rock-surface which might not have been produced by a stone smaller than a walnut.

He saw no reason for doubting that revolving icebergs were capable of scooping out hollows in the rocky bottom of the sea, and thought that lake-basins on the rocky summits of hills or on water-sheds might have been produced in this way. He then gave reasons for supposing that the drift-knolls called *eskers*, where their forms were very abrupt, might have been partly formed by eddying currents with waves generated or intensified by ice-movements, which sometimes would set the sea in motion as much as sixteen miles off.

According to Mr. Mackintosh, floating coast-ice is the principal transporter and glaciator of stones, and the uniformly striated stones found in the bowlder-clay were both glaciated and transported by coast-ice. He entered minutely into a consideration of how stones, previously more or less rounded, became flattened and uniformly grooved on one, two, or more sides, the grooves on the various sides differing in their directions. He believed that many of the stones found in the bowlder-clay of Cheshire must have been frequently dropped and again picked up by coast-ice during the passage from their original positions.

Ancestors of the British.—Another paper by the same author was devoted to the discussion of certain ethnological questions connected with the history of the people of Britain. He believed that the inhabitants of different parts of England and Wales differed so much in their physical and mental characteristics that many tribes must have retained their peculiarities since their colonization of the country, by remaining in certain localities with little mutual interblending, or through the process of amalgamation failing to obliterate the more hardened characteristics. The first type noticed was the Gaelic. In Cæsar's time, probably the great mass of the people of Gaul were comparatively dark in complexion and small in stature; and the race characterized by Cæsar as of tall stature, reddish hair, and blue eyes, were most likely German colonists of Gaul. There still exists in England, Wales, and Ireland, a distinct race, possessed of some of the mental characteristics anciently attributed to the Gaels. In mental character the Gaels are excitable, and alternately lively and melancholy. The Gael is also by temperament an excellent soldier, but he needs to be commanded by a race possessed of moral determination, tempered by judgment and foresight. Another characteristic of the Gaelic race is sociability.

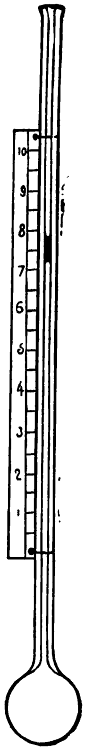
In North Wales there are several distinct ethnological types, but by far the most prevalent is the type to which the term Cymrian may be applied. The Cymri appear to have entered Wales from the north. They are an industrious race, living on scanty fare without murmuring. Mr. Mackintosh gave a minute description of the physical and mental peculiarities of Saxons, and showed the difference between Saxons and Danes. With Worsaae, he believes that the Danes have impressed their character on the inhabitants of the northeastern half of England. He endeavored to show that between the northeast and southwest the difference in the character of the people is so great as to give a semi-nationality to each division. Restless activity, ambition, and commercial speculation, predominate in the northeast; contentment and leisure of reflection in the southwest. He concluded by a reference to the derivation of the settlers of New England from the southwest, mentioning the fact that, while a large proportion of New England surnames are still found in Devon and Dorset, there is a small village, called Boston, near Totnes, and in its immediate neighborhood a place called Bunker Hill.

Changes in the Courses of Rivers.—Major Herbert Wood spoke on the cause of the change of direction in the lower course of the river Oxus, by which its mouth had been diverted from the Caspian to the Aral. In the opinion of Major Wood this change is to be attributed to the abstraction of the water of the river for the purposes of irrigation, which has been practised from time immemorial. The quantity of water thus diverted has never been calculated, but, from data obtained by Major Wood during the Russian Expedition, he concludes that, between June 23 and September 10, 1874, an average of 62,350 cubic feet per second was absorbed by the irrigation canals of Khiva, an amount equal to nearly one-half the total volume of the

Oxus. At the time when the river emptied itself into the Caspian the conditions of its *régime* were such that the volume and velocity of its summer or flood water were sufficient to clear away annually from its bed the deposits of mud resulting from the smaller volume of its winter course. From certain data it is concluded that the difference of the delivery of water between winter and summer is as one to three: thus the bed would not undergo any deterioration, its course would remain unchanged, and the river would continue to discharge itself into the Caspian. But, as soon as the volume and velocity of its summer waters were diminished by the action of irrigation canals, those compensatory arrangements of Nature would be upset, and a proportion of the muddy deposits of winter would escape the annual scouring. In course of time bars would form in the bed of the river, and in the end prevent it extending its course to the Caspian. That the Oxus has changed its lower course is proved by numerous historical documents.

Antiquity of the Divining-Rod.—A paper on "Rabdomancy" (or the use of the "divining-rod") and "Belomancy" (or divination by means of arrows) was read by Miss A. W. Buckland. According to the author, the staff as a sceptre was probably a later form of the horn which was thus used in prehistoric times, and in that character adorned the heads of gods. From this use of rods or horns arose a veneration for them as possessing the power of healing. Hence their use by magicians, whose chief instruments have always been a ring and a staff. These symbols conjoined are found in Egyptian, Assyrian, and Peruvian sculptures, and may be traced in some of the stone circles of Britain and in the shape of ancient Irish brooches. Belomancy, or divination by marked arrows, said to be of Scythian origin, was practised in Babylon, Judea, and Arabia, and traces of it may still be found in the popular tales of Russia and Siberia. "That the arts of magic and divination are a remnant of pre-Aryan religion is proved," said the author, "by their present existence among aboriginal non-Aryan races; and they might even be used as a test of race, so that those who in the counties of Somerset and Cornwall claim the power of divination by the rod might possibly have some remote affinity with the aboriginal inhabitants of Britain."

The Clinical Thermoscope.—Dr. Seguin, of this city, has devised an ingenious little instrument, called the clinical thermoscope, to be used as an aid in diagnosis. It is employed for detecting the variations of temperature on the surface of the body, and estimating the rate of radiation going on therefrom. In the words of the inventor, it is "intended as a quicker and more delicate test of differential temperatures than the thermometer; and less to give the degree of heat than the velocity of its radiation." We present a cut of the instrument half the actual size. It consists of a glass tube seven inches long, with a minute bore open at one end, and terminating at the other in a bulb. An adjustable scale is attached to the outside of the tube. To prepare it for use, immerse the bulb in hot water, which rarefies the air inside. The open end is then plunged into cold water and quickly withdrawn, when a drop or two will be found to have entered the tube. This forms a "water-index," which should become stationary within an inch or two of the bulb. If it falls into the bulb, or does not approach it sufficiently, too much or too little heat was applied in the first instance, and it will be necessary to jar the water from the tube and try again. When the index is provided, adjust the scale, bringing its lowest figure on a level with the top of the column of water in the tube, and it is then ready for use. It may be applied to any part of the surface, where disturbance of temperature is suspected, but its habitual place in the hands of Dr. Seguin is, not the axilla, but the shut hand. The claims



for it are, that it gives by contact indications of the volume of heat escaping by radiation, and the velocity of loss; also, that by blowing on the bulb the degree of combustion that takes place in the lungs is shown. It is likewise serviceable as a means of detecting the exact position of deep-seated local trouble, giving valuable indications where the thermometer fails.

A New Fossil Crustacean.—A new crustacean species, allied to *Eurypterus* and *Pterogotus*, has been described by A. R. Grote and W. H. Pitt, under the name of *Eusarcus scorpionis*. The specimen was found in the water-lime group at Buffalo, N. Y. Its length is 250 millimetres, and its greatest width 110 millimetres. The cephalo-thoracic portion appears to be separate from the body; the legs are in the same number as in *Eurypterus*; the swimming-feet appear to differ by the straighter, less rounded outer margins; the spines of the anterior feet appear to be long, curved, and to have an anterior direction. The absence of chelate appendages to the posterior margin of the feet is particularly noticeable. The first seven broad segments of the abdomen form a large ellipse. There is an evident and remarkable narrowing of the succeeding caudal segments. The interest which attaches to this remarkable crustacean arises from the discovery of a form which may be allowed to be higher than *Eurypterus* and *Pterogotus*.

Reptilian Affinities of Birds.—Prof. E. S. Morse has for a long time made a study of the bones of embryo birds. At this year's meeting of the American Association he recalled briefly the evidence he had shown last year regarding the existence of the intermedium in birds, by citing the embryo tern, in which he had distinctly found it. This year he had made a visit to Grand Menan, expressly to study the embryology of the lower birds, and was fortunate in finding the occurrence of this bone in the petrel, sea-pigeon, and eider-duck. This additional evidence showed beyond question the existence of four tarsal bones in birds as well as four carpal ones. In these investigations he had also discovered embryo claws on two of the fingers of the wing—the index and middle finger. Heretofore in the adult bird a single claw only had occurred in a few species, such as the Syrian blackbird, spur-winged goose, knob-winged dove, jacana, mound-bird, and a few others; and in these cases it occurred either on the index or middle finger, or on the radial side of the metacarpus. All these facts lent additional proofs of the reptilian affinities of birds.

American Pedigree of the Camel.—Though the evolutional pedigree of the horse may be distinctly traced in the succession of equine genera whose remains are found in the Tertiary strata of our Western Territories, nevertheless, the horse, as he at present exists, is not indigenous to this continent, but has been imported from Europe. The pedigree of the camel may also be constructed from materials supplied by American paleontology. Prof. Cope has recently unearthed a number of genera which must be regarded as the ancestors of the camel. And it is worthy of note that, although the more prominent genera of the series which resulted in the horse, for instance *Anchitherium* and *Hippotherium*, have been found in European formations, no well-determined form of the ancestral series of the camel has up to the present time been found in any formation of the Palæarctic region. "Until such are discovered," says Prof. Cope, "there will be much ground for supposing that the camels of the Old World were derived from American ancestors."

Arctic Meteorology.—During Weyprecht and Payer's expedition to the north-polar regions the air in winter seemed always to contain particles of ice. This was seen not only by parhelia and paraselenæ when the sky was clear, but also in astronomical observations. The images of celestial objects were hardly ever as clear and well defined as at lower latitudes, although the actual moisture in the atmosphere was far less than is usual in temperate climes. It happened very often that, with a perfectly clear sky, needles of ice were deposited in great quantities upon all objects. It was impossible to determine the quantity of atmospheric deposits, as during the snow-storms no distinction could be made between the snow actually falling and that raised from the ground by the storm. It was remarkable, however, that during the first winter the quantity of snow was small compared with that of the second winter, when the snow almost completely buried the ship. The same proportion was repeated in the quantity of rain during the first and second summer; in the first only a little rain fell and that late in the year, while in July, 1874, it rained in torrents for days.

Life in Elevated Areas. — The general belief in the invigorating effect of mountain-air is not absolutely justified by facts: at least there are some elevated regions the inhabitants of which show none of the vigor and *élan* which we should expect to find, were the common opinion correct. Dr. Jourdanet, of Paris, writes of the inhabitants of the table-land of Anahuac, Mexico, that they appear quite languid, with pale complexion, ill-developed muscles, and feeble circulation. The mortality of infants is 30 per cent. in the first year after birth. Dr. Jourdanet is satisfied that, while the proportion of red corpuscles in the blood is normal, there is a diminution of oxygen, the result of insufficient condensation of that gas under the slight pressure of the air. For this condition of the blood he proposes the name of *anoxyhæmia*. In Mexico, at the height of about 2,300 metres (7,500 feet) above the sea, the debilitating effects of the rarefied air are manifest. This is noticeable in brutes as well as in men. Again, the annual growth of population is scarcely ever more than three per 1,000 on the uplands, while nearer the sea-level it is six or seven. Dr. Jourdanet asserts his belief that, in countries where cold is not of itself an obstacle to life, rarefaction of the air will prevent the founding of durable states at a level higher than 4,000 metres.

Chinese Wheelbarrows.—In commenting on an improved style of wheelbarrow, a correspondent of the *Gardener's Chronicle* praises the Chinese for the ingenuity they display in diminishing to the last degree the labor of the man who propels the barrow. The Chinese barrow has but one wheel, but it is large, and placed in the centre of the bed of the vehicle; the entire load rests on this central wheel. In Shanghai, thousands of these vehicles ply for hire in the streets, the usual load being two persons, who sit on a wooden platform on each side of the wheel, resting one arm on a framework which rises above the top of the wheel, and planting one foot in a stirrup made of rope. "It is by no means uncommon, however," he adds, "to see as many as four persons conveyed without any particular effort (the ground being level) by a stalwart coolie;" garden and farm produce is transported in the same way, and even live-stock: the Chinese farmer being too sensible to attempt to drive his pigs to market, the barrow is often seen laden with a live fat hog on each side of the wheel.

Cave-Habitations in Kentucky. — That some of the great caves of Kentucky were, temporarily at least, used as places of human habitation, is conclusively shown by Prof. Putnam's exploration of Salt Cave. This cave, says Prof. Putnam, approaches the Mammoth Cave in the size of its avenues and chambers. Throughout one of the principal avenues, for several miles, were to be traced the ancient fireplaces both for hearths and lights. Bundles of fagots were found in several places in the cave. But the most important discovery was made in a small chamber, about three miles from the entrance. On the dry soil of the floor were to be seen the imprints of the sandaled feet of the former race who had inhabited the cave, while a large number of cast-off sandals were found, neatly made of finely-braided and twisted rushes.

The Use of Bushy Tails.—It is easy to see the usefulness to the opossum, monkey, and other animals, of their prehensile tails. So, too, we can recognize the value to the horse and the ox of the switches by means of which these animals repel the attacks of insects. But there are other forms of the tail the uses of which are less evident, for instance, the bushy tail seen in the fox, dog, wolf, cat, etc. Mr. Lawson Tait holds that the use of this bushy appendage is completely analogous to that of the respirator worn by persons troubled with lung-complaints, the object being to abstract from the expired air, by means of fur in the one case, and wire gauze in the other, the heat which is being taken out with it; so that the cold air inspired shall be raised in temperature before it reaches the lungs, and thereby conduce to a conservation of the bodily heat. Some interesting considerations bear on this. Animals provided with bushy tails seem to be so as a matter of correlation of growth, their bodies being always provided with thickly-set and more or less soft fur. "I cannot," says Mr. Tait, "find an animal with a bushy tail which cannot, and does not, lie curled up when asleep. I went round the Zoölogical Gardens at Dublin on a very cold morning in February, and found the civet cat, and some other bushy-tailed animals, coiled up with their noses buried in the fur of their tails.

"In the squirrel this use of the tail is very marked, and in birds the same object is accomplished by their burying their heads in the down of the shoulders. Animals provided with bushy tails are all solitary in their method of living, so far as I can find; and, therefore, an essential for their survival is some method by which variations of temperature shall be resisted. The use of the tail for this purpose is, I think, best of all illustrated in the great ant-eater (*Myrmecophaga jubata*), in which the hairs of the tail reach a very great size, and cover up the animal when reposing, so that he looks like a bundle of dried grass. It may also serve as a protection by mimicry in this case. Mr. Wallace states also that this animal uses its tail as an umbrella in a shower, and that the Indians divert its attention from themselves by rustling the leaves in imitation of a falling shower, and while he is putting up his umbrella they kill him. Of the quadrumana, the marmosets afford a striking instance of a bushy tail as a probable provision for protecting these delicate creatures from depressions of the temperature."

Remedy for Boiler Incrustations.—"Apparatine" is the name given to a substance said to be effectual in preventing incrustation in boilers, and also useful wherever gelatine and gelatine-like substances are required, as in sizing textile fabrics. It is a colorless, transparent material, obtained by treating any amylaceous substance with a caustic alkali. It is best made, however, with potato-starch, treated with a lye of caustic potash or soda. The best method of preparing the apparatine is as follows: 16 parts of potato-starch are put into 76 parts of water, and kept in a state of suspension by stirring; then 8 parts of potash or soda-lye at 25° Baumé are added, and the whole thoroughly mixed. In a few seconds the mixture suddenly clears, forming a thick jelly, which must be beaten up vigorously. It is now a colorless, transparent substance, slightly alkaline in taste, but odorless, and of a stringy, glue-like consistency. Exposed to the air, it dries slowly, but without decomposing; and even when heated to dryness, although it thickens and swells, it continues unchanged, as when air-dried.

To prevent incrustation, the apparatine may be placed in the boiler or added to the feed-water in the tank; but the best results have been obtained by placing it directly in the boiler. Applied to silk, woolen, and cotton goods, it gives them a smoothness hitherto unattainable. When once applied to the goods, and become dry, it appears to be virtually insoluble. Diaphanous or coarsely-woven fabrics, when dressed with apparatine, are rendered stiff and rigid. It may be used as a thickening in calico-printing.

NOTES.

A CORRESPONDENT of the *Scientific American* states that in Minneapolis a supply of water for extinguishing fires is obtained in localities beyond the reach of the city water-works by sinking four drive-wells at distances thirty feet apart, or fifteen feet from a centre. The pipes (2½ inches) of the four wells are brought together at the top, where the suction-hose of the fire-engine is attached. On trial an engine threw a continuous stream from a 1⅛-inch nozzle for one hour. The water in the tubes was then at the same height as at the beginning.

THE chaparral-hen is described by a sportsman in Texas as a very pretty bird. The female lays one egg, and then commences sitting. While sitting she lays four more, the first being the largest and the fifth the smallest. The birds, when grown, seem to be of the same size. By the time the fifth egg is hatched the first is nearly a full-fledged bird. The first egg is about the size of a pheasant's; the others range in size between the pheasant's and the quail's egg.

A MASS of native copper, in weight 6,000 pounds, and taken from an ancient mine on Isle Royal, Lake Superior, is now on exhibition in St. Louis. The mass had evidently been detached from its bed by the ancient miners.

FROM calculations made by Dr. J. T. Luck, of St. Louis, it appears that the death-rate among officers of the United States Navy is astonishingly high, being last year 25.45 per thousand. Assuming the average age of naval officers to be thirty, the death-rate is three times as high as that of civilians.

THE growing appreciation of American scientific work in France is evidenced by the action of the Minister of Public Works authorizing an exchange of the *Annales des Mines* with sundry American journals and publications of scientific bodies.

To encourage local collectors and amateurs of science in the work of determining the ichthyology of Indiana, Prof. D. S. Jordan, of the State Geological Survey, has published a preliminary list of the fishes which he has himself found, and adds a list of those likely to occur in Indiana waters.

AT the initial meeting of the Khedival Society of Geography, held June 2d, the Khedive was represented by his second son, Hussein Pasha, and there were present most of the prominent representatives of the foreign colony in Cairo. The president, Dr. Schweinfurth, addressed the meeting in French. "Science," said he, "which had been carried from Egypt into Greece and Italy, and thence into Central Europe, was now returning to its birthplace. By the munificence of the Khedive, a society had now been established whose object it would be to advance the oldest, the most universal, and the most popular of the sciences. Unlike its sister associations in Europe and America, which have their field of research in distant lands, the Khedival Society had all its work to do at home, so to speak."

IN a lecture at Edinburgh on carnivorous plants, Dr. Balfour stated that young plants of *Dionœa muscipula* under bell-glasses do not thrive so well as those left free, and that while a piece of beef wrapped in another leaf becomes putrid, a piece inclosed by the *Dionœa* remains perfectly inodorous, but soon loses its red color, and is gradually disintegrated more and more till it is reduced to a pulp.

PALLADIUM, when coated with palladium-black, becomes saturated with hydrogen much more rapidly than the clean metal. If, when thus saturated, it be wrapped in gun-cotton, an explosion ensues after a few seconds, and the platinum plate burns for a short time with a feeble flame.

EXPERIMENTS made by Pfaff show ice to be by no means a bad conductor of heat. Taking the conductivity of gold as 1,000, platinum is 981, silver 973, iron 374, ice 314, and tin 303. Dr. Pfaff suggests that his results will modify our views of the physical condition of the interior of a mass of ice.

FROM the observations of Ebermeyer it appears that, in a given species of tree, the size of the leaves differs in proportion to the elevation. With equal strength of soil, the leaves decrease with height. Again, the entire amount of ash in the leaves decreases with the height; and the proportion of phosphoric acid in the ash is much less in high positions than on low ground.

STATUETTES and other artistic forms in plaster are made very closely to resemble silver in appearance by being covered with a thin coat of powdered mica. This powder is mixed with collodion and then applied to the objects in plaster with a brush, after the manner of paint. The mica can be easily tinted in various colors. It can be washed in water, and, unlike silver, is not liable to become tarnished by sulphuretted gases.

IN Great Britain and Ireland, the excise duties on liquors for the year ending March, 1875, amounted to £31,917,849, being an increase of £600,000 over the previous financial year.

"So popular are Mr. Darwin's books," says the *English Mechanic*, "and so widely read, that a countryman with a basket of round-leaved sundews (*Drosera rotundifolia*) has stationed himself near the Royal Exchange in London, and there daily drives a very good trade."

THE excellent Abbé Moigno, editor of *Les Mondes*, and general manager of the Catholic enterprise for diffusing a knowledge of science among the laboring-classes in France, has issued a work entitled "Explosions of Freethinking in August and September, 1874," containing the discourses of Tyndall, Du Bois-Reymond, R. Owen, Huxley, Hooker, and Sir John Lubbock. The abbé appends annotations of his own. This is as it should be: poison and antidote!

IT is asserted by E. Heckel, as the result of experiments made upon certain rodents and marsupials, that these animals, when fed on the leaves of poisonous solanaceous plants, are not subject to any injurious effects.

A COMMITTEE appointed for the purpose of investigating the working of the government telegraph system in England reports that the present rate, one shilling per message, is too low, and recommends that it be increased fifty per cent. The *Examiner*, on the contrary, asserts that only by a *reduction* of fifty per cent. can the telegraph service be made self-sustaining. Such reduction, it is claimed, would have the same result as cheap postal rates.

From experiments made on a large number of animals belonging to different orders, Rudolph Pott concludes that, of all animals, birds exhale the greatest amount, proportionately, of carbonic acid; after birds rank the mammalia, and then insects. Worms, amphibia, fishes, and snails, exhale much less carbonic acid than birds, mammals, or insects. The influence of age on carbonic-acid excretion is very marked: thus, for example, an old mouse exhaled in a given time 3.873 grammes, a young one 4.349. But with insects the case is different, old individuals exhaling more carbonic acid than young.

In Turkey, Russia, and Peru, the number of pupils receiving primary instruction in schools forms from ¼ to ½ per cent. of the population; in Spain, 1 per cent.; in Italy, 6; in Hungary, 7½; in Austria, 9; in England and in Norway, 12; in France, 13; in Prussia, 15; in the United States, 17.

On subjecting fishes to a pressure of ten atmospheres, Moreau found that the operation produced no injurious effects whatever. He then suddenly withdrew the pressure, and the fishes succumbed quickly from hæmorrhage, the blood having a frothy appearance. This phenomenon is due to the disengagement of the gases which, under the high pressure, had been taken up by the blood in great quantities.

It is stated in *Iron* that De la Bastie's glass loses its molecular cohesion under a repetition of blows, and then breaks like common glass. Tempered glass, submitted to hammering, presents an appearance on fracture similar to that of *fatigué* steel, a molecular disintegration having taken place. It is feared that this alteration of structure and loss of temper may not only follow from shock, but may happen spontaneously from interior change in the lapse of time.

A recent examination of the hull of the steamship Great Eastern showed a comparative absence of barnacles, though the stern-post, rudder, and screw were covered with them. The rest of that portion of the hull, which as a rule is below water, was clad with an enormous number of mussels, a surface of 52,000 feet being coated in parts to a depth of six inches. The total weight of the mussels is estimated at about 300 tons.

The income of the French Association last year was 37,126 francs, and its capital fund now amounts to 174,731 francs. The Association gained 500 new members at its last meeting. Though the strictest economy must needs have been practised to accumulate so considerable a fund as 175,000 francs, nevertheless the *material* encouragement of scientific investigators is not neglected. Last year 12,350 francs were distributed for purposes of research.

Hitherto batrachians of existing types have been regarded as of recent geological date—not earlier than the Tertiary epoch. Recently, however, batrachian remains were discovered in palæozoic rocks at Igornay (Saône-et-Loire), France. These remains have been described by A. Gaudry, who discovers in them affinities with the salamanders. Though the specimens appear to be adult, they are very small—a little over one inch in length. They occur in bituminous schists of the Permian age.

As a substitute for the dredge in removing sand-banks and other deposits from rivers, a French engineer proposes to employ metal pipes pierced with holes; these pipes are inserted into the mass of the sand-bank and water driven through them at considerable pressure. In this way the sand and mud would be raised and agitated, and carried away by the current of the river or by the ebb-tide, if the operation were conducted at the ebb.

According to Boillot, a French chemist, the bleaching effects usually attributed to chlorine are in reality due to ozone. Ozone employed directly acts as an oxidizing agent, laying hold of the hydrogen of the substance with which it is in contact, whence results bleaching if the body is colored. On allowing chlorine to act upon any animal or vegetable matter, it decomposes a certain quantity of water and seizes its hydrogen, forming hydrochloric acid. The oxygen set free by this reaction is transformed into ozone, which in its turn lays hold of hydrogen present in organic matter.

Actual experiment in England has demonstrated the great advantages of the hammock system of conveying invalids by railway. The invalid suffers neither jar nor jolt. It is proposed to extend the benefits of the hammock system to the general traveling public, thus reducing the discomfort of railway-travel to the minimum.

The cultivation of tea is making rapid progress in Ceylon, and extensive clearings of forest-land were made during the past year for forming new plantations. The seed is generally imported from India, though the Assam hybrid and China teas are also cultivated extensively.

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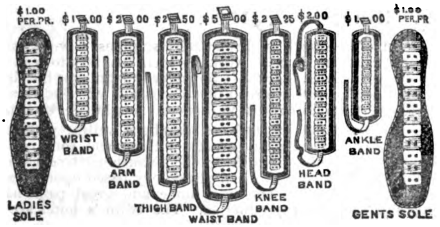

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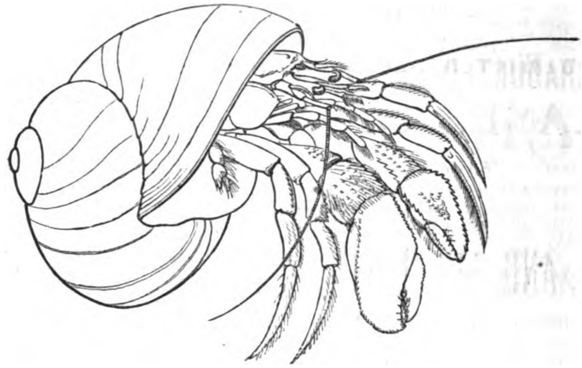

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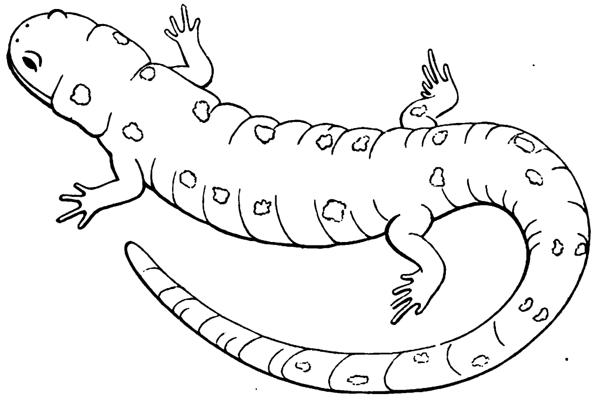

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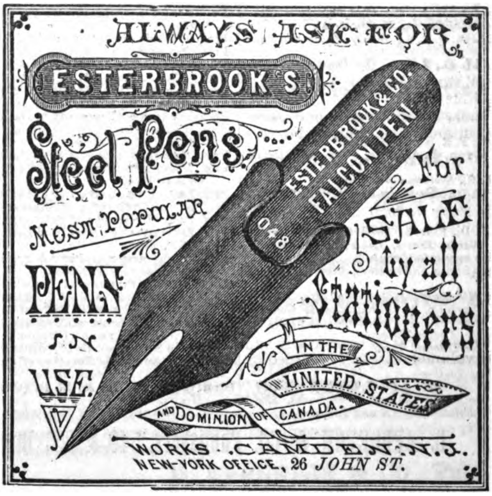

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THE

POPULAR SCIENCE

MONTHLY.

FEBRUARY, 1876.

THE WARFARE OF SCIENCE.

By ANDREW D. WHITE, LL. D.,
PRESIDENT OF CORNELL UNIVERSITY.

I.

I PURPOSE to present an outline of the great, sacred struggle for the liberty of science—a struggle which has lasted for so many centuries, and which yet continues. A hard contest it has been; a war waged longer, with battles fiercer, with sieges more persistent, with strategy more shrewd than in any of the comparatively petty warfares of Cæsar or Napoleon or Moltke.

I shall ask you to go with me through some of the most protracted sieges, and over some of the hardest-fought battle-fields of this war. We will look well at the combatants; we will listen to the battle-cries; we will note the strategy of leaders, the cut and thrust of champions, the weight of missiles, the temper of weapons.

My thesis, which, by an historical study of this warfare, I expect to develop, is the following: *In all modern history, interference with science in the supposed interest of religion, no matter how conscientious such interference may have been, has resulted in the direst evils both to religion and to science, and invariably. And, on the other hand, all untrammeled scientific investigation, no matter how dangerous to religion some of its stages may have seemed, for the time, to be, has invariably resulted in the highest good of religion and of science.* I say "invariably." I mean exactly that. It is a rule to which history shows not one exception

It would seem, logically, that this statement cannot be gainsaid. God's truths must agree, whether discovered by looking within upon the soul, or without upon the world. A truth written upon the human heart to-day, in its full play of emotions or passions, cannot be

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[1] In its earlier form this address was given as a Phi Beta Kappa oration at Brown University, and as a lecture at New York, Boston, New Haven, Ann Arbor, and elsewhere.

at any real variance even with a truth written upon a fossil whose poor life ebbed forth millions of years ago.

This being so, it would also seem a truth irrefragable, that the search of each of these kinds of truth must be followed out on its own lines, by its own methods, to its own results, without any interference from investigators on other lines, or by other methods. And it would also seem logical to work on in absolute confidence that whatever, at any moment, may seem to be the relative positions of the two different bands of workers, they must at last come together, for Truth is one.

But logic is not history. History is full of interferences which have cost the earth dear. Strangest of all, some of the direst of them have been made by the best of men, actuated by the purest motives, and seeking the noblest results. These interferences, and the struggle against them, make up the warfare of science.

One statement more, to clear the ground. You will not understand me at all to say that religion has done nothing for science. It has done much for it. The work of Christianity, despite the clamps which men have riveted about it, has been mighty indeed. Through these two thousand years, it has undermined servitude, mitigated tyranny, given hope to the hopeless, comfort to the afflicted, light to the blind, bread to the starving, joy to the dying, and this work continues. And its work for science, too, has been great. It has fostered science often. Nay, it has nourished that feeling of self-sacrifice for human good, which has nerved some of the bravest men for these battles.

Unfortunately, some good men started centuries ago with the idea that purely scientific investigation is unsafe—that theology must intervene. So began this great modern war.

The first typical battle-field to which I would refer is that of Geography—the simplest elementary doctrine of the earth's shape and surface.

Among the legacies of thought left by the ancient world to the modern, were certain ideas of the rotundity of the earth. These ideas were vague; they were mixed with absurdities; but they were *germ ideas*, and, after the barbarian storm which ushered in the modern world had begun to clear away, these germ ideas began to bud and bloom in the minds of a few thinking men, and these men hazarded the suggestion that the earth is round—is a globe.[1]

The greatest and most earnest men of the time took fright at once. To them, the idea of the earth's rotundity seemed fraught with dangers to Scripture: by which, of course, they meant *their interpretation* of Scripture.

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[1] Most fruitful among these were those given by Plato in the "Timæus." *See*, also, Grote on Plato's doctrine of the rotundity of the earth. Also Sir G. C. Lewis's "Astronomy of the Ancients," London, 1862, chap. iii., sec. i. and note. Cicero's mention of the antipodes and reference to the passage in the "Timæus" are even more remarkable than the original, in that they much more clearly foreshadow the modern doctrine. *See* "Academic Questions," ii., xxix. Also, "Tusc. Quest.," i., xxviii., and v., xxiv.

Among the first who took up arms against the new thinkers was Eusebius. He endeavored to turn off these ideas by bringing science into contempt. He endeavored to make the innovators understand that he and the fathers of the Church despised all such inquiries. Speaking of the innovations in physical science, he said: "It is not through ignorance of the things admired by them, but through contempt of their useless labor, that we think little of these matters, turning our souls to better things."[1]

Lactantius asserted the ideas of those studying astronomy to be "mad and senseless."[2]

But the attempt to "flank" the little phalanx of thinkers did not succeed, of course. Even such men as Lactantius and Eusebius cannot pooh-pooh down a new scientific idea. The little band of thinkers went on, and the doctrine of the rotundity of the earth naturally led to the consideration of the tenants of the earth's surface, and another germ idea was[3] warmed into life—the idea of the existence of the antipodes, the idea of the existence of countries and men on the hemisphere opposite to ours.

At this the war spirit waxed hot. Those great and good men determined to fight. To all of them such doctrines seemed dangerous; to most of them they seemed damnable. St. Basil and St. Ambrose[4] were tolerant enough to allow that a man might be saved who believed the earth to be round, and inhabited on its opposite sides; but the great majority of the Fathers of the Church utterly denied the possibility of salvation to such misbelievers.

Lactantius asks ". . . Is there any one so senseless as to believe that there are men whose footsteps are higher than their heads?—that the crops and trees grow downward?—that the rains and snow and hail fall upward toward the earth? . . . But if you inquire from those who defend these marvelous fictions, why all things do not fall into that lower part of the heaven, they reply that such is the nature of things, that heavy bodies are borne toward the middle, like the spokes of a wheel; while light bodies, such as clouds, smoke, and fire, tend from the centre toward the heavens on all sides. Now, I am at loss what to say of those who, when they have once erred, steadily persevere in their folly, and defend one vain thing by another."

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[1] *See* Eusebius, "Præp. Ev.," xv., 61.

[2] *See* Lactantius, "Inst.," l., iii., chap. 3. Also, citations in Whewell, "Hist. Induct. Sciences," Lond., 1857, vol. i., p. 194. To understand the embarrassment thus caused to scientific men at a later period, *see* "Letter of Agricola to Joachimus Vadianus" in 1514. Agricola asks Vadianus to give his views regarding the antipodes, saying that he himself does not know what to do, between the Fathers on one side and learned men of modern times on the other. On the other hand, for the embarrassment caused to the Church by this mistaken zeal of the Fathers, *see* Kepler's references and Fromund's replies; also De Morgan, "Paradoxes," p. 58. Kepler appears to have taken great delight in throwing the views of Lactantius into the teeth of his adversaries.

[3] "Another germ idea," etc. *See* Plato, "Timæus," 62 C., Jowett's translation, N. Y. ed. Also "Phædo," pp. 449, *et seq.* Also Cicero, "Academic Quest.," and "Tusc. Disput.," *ubi supra.* For citations and summaries, *see* Whewell, "Hist. Induct. Sciences," vol. i., p. 189, and St. Martin, "Hist. de la Géog.," Paris, 1873, p. 96. Also Leopardi, "Saggio sopra gli errori popolari degli antichi," Firenze, 1851, chap. xii., p. 184, *et seq.*

[4] For opinion of Basil, Ambrose and others, *see* Lecky, "Hist. of Rationalism in Europe," New York, 1872, vol. i., p. 279, note. Also Letronne, in *Revue des Deux Mondes*, March, 1834.

Augustine seems inclined to yield a little in regard to the rotundity of the earth, but he fights the idea that men exist on the other side of the earth, saying that "Scripture speaks of no such descendants of Adam."

But this did not avail to check the idea. What may be called the flank movement, as represented by Eusebius, had failed. The direct battle given by Lactantius, Augustine, and others, had failed. In the sixth century, therefore, the opponents of the new ideas built a great fortress and retired into that. It was well built and well braced. It was nothing less than a complete theory of the world, based upon the literal interpretation of texts of Scripture, and its author was Cosmas Indicopleustes.[1]

According to Cosmas, the earth is a parallelogram, flat, and surrounded by four great seas. At the outer edges of these seas rise immense walls closing in the whole structure. These walls support the vault of the heavens, whose edges are cemented to the walls; walls and vault shut in the earth and all the heavenly bodies. The whole of this theologic, scientific fortress was built most carefully, and, as was then thought, most scripturally.

Starting with the expression, To ἅγιον κοσμικόν, applied in the ninth chapter of Hebrews to the tabernacle in the desert, he insists, with other interpreters of his time, that it gives a key to the whole construction of the world. The universe is, therefore, made on the plan of the Jewish Tabernacle—box-like and oblong.

Coming to details, he quotes those grand words of Isaiah,[2] "It is he that sitteth upon the circle of the earth, . . . that stretcheth out the heavens like a curtain, and spreadeth them out like a tent to dwell in," and the passage in Job,[3] which speaks of the "pillars of heaven." He turns all that splendid and precious poetry into a prosaic statement, and gathers therefrom, as he thinks, treasures for science.

This vast box is then divided into two compartments, one above the other. In the first of these, men live and stars move; and it extends up to the first solid vault or firmament, where live the angels, a main part of whose business it is to push and pull the sun and planets to and fro. Next he takes the text, "Let there be a firmament in the midst of the waters, and let it divide the waters from the waters," and other texts from Genesis.[1] To these he adds the texts from the Psalms, "Praise him ye heaven of heavens, and ye waters that be above the heavens,"[2] casts that outburst of poetry into his crucible with the other texts, and, after subjecting them to sundry peculiar processes, brings out the theory that over this first vault is a vast cistern containing the waters. He then takes the expression in Genesis regarding the "windows of heaven,"[3] and establishes a doctrine regarding the regulation of the rain, which is afterward supplemented by the doctrine that the angels not only push and pull the heavenly bodies, to light the earth, but also open and close the windows of heaven to water it.

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[1] For Lactantius, *see* "Instit.," iii., 24, translation in Ante-Nicene Library; also, citations in Whewell, i., 196, and in St. Martin, "Histoire de la Géographie," pp. 216, 217. For St. Augustine's opinion, *see* the "Civ. D.," xvi., 9, where this great Father of the Church shows that the existence of the antipodes "*nulla ratione credendum est.*" Also, citations in Buckle's "Posthumous Works," vol. ii., p. 645.

[2] Isaiah xl. 22.

[3] Job xxvi. 11.

To find the character of the surface of the earth, Cosmas studies the table of shew-bread in the Tabernacle. The dimensions of that table prove to him that the earth is flat and twice as long as broad. The four corners of the table symbolize the four seasons.

To account for the movement of the sun, Cosmas suggests that at the north of the earth is a great mountain, and that, at night, the sun is carried behind this. But some of the commentators ventured to express a doubt here. They thought that the sun was pushed into a great pit at night, and was pulled out in the morning.

Nothing can be more touching in its simplicity than Cosmas's closing of his great argument. He bursts forth in raptures, declaring that Moses, the prophets, evangelists, and apostles, agree to the truth of his doctrine.[4]

Such was the fortress built against human science in the sixth century, by Cosmas; and it stood. The innovators attacked it in vain. The greatest minds in the Church devoted themselves to buttressing it with new texts, and throwing out new outworks of theologic reasoning. It stood firm for two hundred years, when a bishop—Virgilius of Salzburg—asserts his belief in the existence of the antipodes.

It happened that there then stood in Germany, in the first years of the eighth century, one of the greatest and noblest of men—St. Boniface. His learning was of the best then known; in labors he was a worthy successor to the apostles; his genius for Christian work made him, unwillingly, Primate of Germany; his devotion afterward led him, willingly, to martyrdom. There sat, too, at that time, on the papal throne, a great Christian statesman—Pope Zachary. Boniface immediately declares against the revival of such a terrible heresy as the existence of the antipodes. He declares that it amounts to the declaration that there are men on the earth beyond the reach of the means of salvation; he attacks Virgilius; he calls on Zachary for aid; effective measures are taken, and we hear no more of Virgilius or his doctrine.

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[1] Genesis i. 6. [2] Psalm cxlviii. 4. [3] Genesis vii. 11.

[4] *See* Montfaucon, "Collectio Nova Patrum," Paris, 1706, vol. ii., p. 188; also, pp. 298, 299. The text is illustrated with engravings showing walls and solid vault (firmament), with the whole apparatus of "fountains of the great deep," "windows of heaven," angels, and the mountain behind which the sun is drawn. For an imperfect reduction of one of them, *see* article "Maps," in Knight's "Dictionary of Mechanics," New York, 1875. For still another theory, very droll, and thought out on similar principles, *see* Mungo Park, cited in De Morgan, "Paradoxes," 309. For Cosmas's joyful summing up, *see* Montfaucon, "Collectio Nova Patrum," vol. ii., p. 255.

Six hundred years pass away, and in the fourteenth century two men publicly assert the doctrine. The first of these, Peter of Abano, escapes punishment by natural death; the second, known as Cecco d'Ascoli, a man of seventy years, is burned alive. Nor was that all the punishment: that great painter, Orcagna, whose terrible works you may see on the walls of the Campo Santo at Pisa, immortalized Cecco by representing him in the flames of hell.[1]

Still the idea lived and moved, and a hundred years later we find the theologian Tostatus protesting against the doctrine of the antipodes as "unsafe." He has invented a new missile—the following syllogism: "The apostles were commanded to go into all the world, and to preach the gospel to every creature. They did not go to any such part of the world as the antipodes, they did not preach to any creatures there: *ergo*, no antipodes exist." This is just before the time of Columbus.

Columbus is the next warrior. The world has heard of his battles: how the Bishop of Ceuta worsted him in Portugal; how at the Junta of Salamanca the theologians overwhelmed him with quotations from the Psalms, from St. Paul, and from St. Augustine.[2]

But in 1519 Science gains a crushing victory. Magalhaens makes his famous voyages. He has proved the earth to be round; for his great expedition has circumnavigated it. He proves the doctrine of the antipodes, for he sees the men of the antipodes.[3] But even this does not end the war. Many earnest and good men oppose the doctrine for two hundred years longer. Then the French astronomers make their measurements of degrees in equatorial and polar regions and add to other proofs that of the lengthened pendulum. When this was done, when the deductions of science were seen to be established by the simple test of measurement, beautifully, perfectly, then and then only this war of twelve centuries ended.[1]

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[1] Virgil of Salzburg. *See* Neander's "History of the Christian Church," Torrey's translation, vol. iii., p. 63. Since Bayle, there has been much loose writing about Virgil's case. *See* Whewell, p. 197; but for best choice of authorities and most careful winnowing out of conclusions, *see* De Morgan, pp. 24–26. For very full notes as to pagan and Christian advocates of doctrine of rotundity of the earth and of antipodes, and for extract from Zachary's letter, *see* Migne, "Patrologia," vol. vi., p. 426, and vol. xli., p. 487. For Peter of Abano, or Apono, as he is often called, *see* Tiraboschi; also Ginguené, vol. ii., p. 293. Also Naudé, "Histoire des grands hommes accusés de Magie." For Cecco d'Ascoli, *see* Montucla, "Histoire des Mathématiques," i., 528; also, Daunou, "Études Historiques," vol. vi., p. 320. Concerning Orcagna's representation of Cecco in flames of hell, *see* Renan, "Averroès et l'Averroisme," Paris, 1867, p. 328.

[2] For Columbus before the Junta of Salamanca, *see* Irving's "Columbus," Murray's, edition, vol. ii., pp. 405–410. Figuier, "Savants du Moyen Age," etc., vol. ii., p. 394, *et seq.* Also Humboldt, "Histoire de la Géographie du Nouveau Continent."

[3] For effect of Magalhaens's voyages, and the reluctance to yield to proof, *see* Henri Martin, "Histoire de France," vol. xiv., p. 395; St. Martin's "Histoire de la Géog.,"

And now what was the result of this war? The efforts of Eusebius and Lactantius to deaden scientific thought; the efforts of Augustine to combat it; the efforts of Cosmas to stop it by dogmatism; the efforts of Boniface, and Zachary, and others to stop it by force, conscientious as they all were, had resulted in what? Simply in forcing into many noble minds this most unfortunate conviction, that Science and Religion are enemies; simply in driving away from religion hosts of the best men in all those centuries. The result was wholly bad. No optimism can change that verdict.

On the other hand, what was gained by the warriors of science for religion? Simply, a far more ennobling conception of the world, and a far truer conception of Him who made and who sustains it.

Which is the more consistent with a great, true religion—the cosmography of Cosmas, or that of Isaac Newton? Which presents the nobler food for religious thought—the diatribes of Lactantius, or the astronomical discourses of Thomas Chalmers?

The next great battle was fought on a question relating to the *position of the earth among the heavenly bodies.* On one side, the great body of conscientious religious men planted themselves firmly on the geocentric doctrine—the doctrine that the earth is the centre, and that the sun and planets revolve about it. The doctrine was old, and of the highest respectability.[2] The very name, Ptolemaic theory, carried weight. It had been elaborated until it accounted well for the phenomena. Exact textual interpreters of Scripture cherished it, for it agreed with the letter of the sacred text.[3]

Still the germs of the heliocentric theory[4] had been planted long before, and well planted; it had seemed ready even to bloom forth

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p. 369; Peschel, "Geschichte des Zeitalters der Entdeckungen," concluding chapters; and for an admirable summary, Draper, "Hist. Int. Dev. of Europe," pp. 451–453.

[1] For general statement as to supplementary proof by measurement of degrees, and by pendulum, *see* Somerville, "Phys. Geog.," chapter i., § 6, note. Also Humboldt, "Cosmos," vol. ii., p. 736, and v., pp. 16, 32. Also, Montucla, iv., 138.

[2] "Respectability of Geocentric Theory, Plato's Authority for it," etc., *see* Grote's "Plato," vol. iii., p. 257. Also, Sir G. C. Lewis, "Astronomy of the Ancients," chap. iii., sec. i., for a very thoughtful statement of Plato's view, and differing from ancient statements. For plausible elaboration of it, *see* Fromundus, "Anti-Aristarchus," Antwerp, 1631. Also Melanchthon "Initia Doctrinæ Physicæ."

[3] For supposed agreement of Scripture with Ptolemaic theory, *see* Fromundus, *passim*, Melanchthon, and a host of other writers.

[4] For "Germs of Heliocentric Theory planted long before," etc., *see* Sir G. C. Lewis; also, Draper, "Intellectual Development of Europe," p. 512. For germs among thinkers

from the mind of Cardinal de Cusa; but the chill of dogmatism was still over the earth, and up to the beginning of the sixteenth century there had come to this great truth neither bloom nor fruitage.[1]

Quietly, however, the soil was receiving enrichment, and the air warmth. The processes of mathematics were constantly improved, the heavenly bodies were steadily though silently observed, and at length appeared, afar off from the centres of thought, on the borders of Poland, a plain, simple-minded scholar, who first fairly uttered to the world the truth, now so commonplace, then so astounding, that the sun and planets do not revolve about the earth, but that the earth and planets revolve about the sun, and that man was Nicholas Kopernik.[2]

Kopernik had been a professor at Rome, but, as this truth grew within him, he seemed to feel that at Rome he was no longer safe.[3]

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of India, *see* Whewell, vol. i., p. 277. Also, Whitney, "Oriental and Linguistic Studies," New York, 1874. "Essay on the Lunar Zodiac," p. 345.

[1] For general statement of De Cusa's work, *see* Draper, "Intellectual Development of Europe," p. 512. For skillful use of De Cusa's view in order to mitigate censure upon the Church for its treatment of Copernicus's discovery, *see* an article in the *Catholic World*, for January, 1869. For a very exact statement, in a spirit of judicial fairness, *see* Whewell, "History of the Inductive Sciences," p. 275 and pp. 379, 380. In the latter, Whewell cites the exact words of De Cusa in the "De Docta Ignorantia," and sums up in these words: "This train of thought might be a preparation for the reception of the Copernican system; but it is very different from the doctrine that the sun is the centre of the planetary system." In the previous passage, Whewell says that De Cusa "propounded the doctrine of the motion of the earth, more, however, as a paradox than as a reality. We cannot consider this as any distinct anticipation of a profound and consistent view of the truth."

[2] For improvement of mathematical processes, *see* Draper, "Intellectual Development of Europe," 513. In looking at this and other admirable summaries, one feels that Prof. Tyndall was not altogether right in lamenting, in his farewell address at New York, that Dr. Draper has devoted so much of his time to historical studies.

[3] Copernicus's danger at Rome. The *Catholic World* for January, 1869, cites a recent speech of the Archbishop of Mechlin before the University of Louvain, to the effect that Copernicus defended his theory, at Rome, in 1500, before two thousand scholars; also, that another professor taught the system in 1528, and was made Apostolic Notary by Clement VIII. All this, even if the doctrines taught were identical with those of Copernicus, as finally developed, which idea Whewell seems utterly to disprove, avails nothing against the overwhelming testimony that Copernicus felt himself in danger—testimony which the after-history of the Copernican theory renders invincible. The very title of Fromundus's book, already cited, published within a few miles of the archbishop's own cathedral, and sanctioned expressly by the theological Faculty of that same University of Louvain in 1630, utterly refutes the archbishop's idea that the Church was inclined to treat Copernicus kindly. The title is as follows:

"Anti-Aristarchus | Sive | Orbis-Terræ | Immobilis | In quo decretum S. Congregationis S. R. E. | Cardinalium | IↃC. XVI adversus Pytha | gorico-Copernicanos editum defenditur | Antwerpiæ MDCXXXI."

L'Epinois, "Galilée," Paris, 1867, lays stress, p. 14, on the broaching of the doctrine by De Cusa, in 1435, and by Widmanstadt, in 1533, and their kind treatment by Eugenius IV. and Clement VII., but this is absolutely worthless in denying the papal policy afterward. Lange, "Geschichte des Materialismus," vol. i., pp. 217, 218, while

To publish this thought was dangerous indeed, and for more than thirty years it lay slumbering in the minds of Kopernik and the friends to whom he had privately intrusted it.

At last he prepares his great work on the "Revolution of the Heavenly Bodies," and dedicates it to the pope himself. He next seeks a place of publication. He dares not send it to Rome, for there are the rulers of the older Church ready to seize it. He dares not send it to Wittenberg, for there are the leaders of Protestantism no less hostile. He therefore intrusts it to Osiander, of Nuremberg.[1]

But, at the last moment, the courage of Osiander failed him. He dared not launch the new thought boldly. He writes a groveling preface; endeavors to excuse Kopernik for his novel idea. He inserts the apologetic lie that Kopernik propounds the doctrine of the movement of the earth, not as a *fact*, but as an *hypothesis*. He declares that it is lawful for an astronomer to indulge his *imagination*, and that this is what Kopernik has done.

Thus was the greatest and most ennobling, perhaps, of scientific truths—a truth not less ennobling to religion than to science—forced, in coming into the world, to sneak and crawl.[2]

On the 24th of May, 1543, the newly-printed book first arrived at the house of Kopernik. It was put into his hands; but he was on his death-bed. A few hours later he was beyond the reach of those mistaken, conscientious men, whose consciences would have blotted his reputation, and perhaps have destroyed his life.

Yet not wholly beyond their reach. Even death could not be trusted to shield him. There seems to have been fear of vengeance upon his corpse, for on his tombstone was placed no record of his life-long labors, no mention of his great discovery. There were graven upon it affecting words, which may be thus simply trans-

admitting that De Cusa and Widmanstadt sustained this idea and received honors from their respective popes, shows that, when the Church gave it serious consideration, it was condemned. There is nothing in this view unreasonable. It would be a parallel case to that of Leo X., at first inclined toward Luther and the others, in their "squabbles with the begging friars," and afterward forced to oppose them.

[1] For dangers at Wittenberg, *see* Lange, "Geschichte des Materialismus," vol. i., p. 217.

[2] Osiander, in a letter to Copernicus, dated April 20, 1541, had endeavored to reconcile him to such a procedure, and ends by saying, "Sic enim placidiores reddideris peripatheticos et theologos quos contradicturos metuis." *See* Apologia Tychonis in "Kepleri Opera Omnia," Frisch's edition, vol. i., p. 246. Kepler holds Osiander entirely responsible for this preface. Bertrand, in his "Fondateurs de l'Astronomie Moderne," gives its text, and thinks it possible that Copernicus may have yielded "in pure condescension toward his disciple." But this idea is utterly at variance with expressions in Copernicus's own dedicatory letter to the pope, which follows the preface. For a good summary of the argument, *see* Figuier, "Savants de la Renaissance," pp. 378, 379. *See* also, citation from Gassendi's life of Copernicus, in Flammarion, "Vie de Copernic," p. 124. Mr. John Fiske, accurate as he usually is, in his recent "Outlines of Cosmic Philosophy," appears to have fallen into the error of supposing that Copernicus, and not Osiander, is responsible for the preface.

lated: "I ask not the grace accorded to Paul, not that given to Peter; give me only the favor which thou didst show to the thief on the cross." Not till thirty years after did a friend dare write on his tombstone a memorial of his discovery.[1]

The book was taken in hand at once by the proper authorities. It was solemnly condemned: to read it was to risk damnation; and the world accepted the decree.[2]

Doubtless many will at once exclaim against the Roman Catholic Church for this. Justice compels me to say that the founders of Protestantism were no less zealous against the new scientific doctrine. Said Martin Luther: "People gave ear to an upstart astrologer, who strove to show that the earth revolves, not the heavens or the firmament, the sun and the moon. Whoever wishes to appear clever must devise some new system which of all systems is, of course, the very best. This fool wishes to reverse the entire science of astronomy. But Sacred Scripture tells us that Joshua commanded the sun to stand still, and not the earth."

Melanchthon, mild as he was, was not behind Luther in condemning Kopernik. In his treatise, "Initia Doctrinæ Physicæ," he says: "The eyes are witnesses that the heavens revolve in the space of twenty-four hours. But certain men, either from the love of novelty, or to make a display of ingenuity, have concluded that the earth moves; and they maintain that neither the eighth sphere nor the sun revolves. . . . Now, it is a want of honesty and decency to assert such notions publicly, and the example is pernicious. It is the part of a good mind to accept the truth as revealed by God, and to acquiesce in it." Melanchthon then cites passages from the Psalms and from Ecclesiastes which he declares assert positively and clearly that the earth stands fast, and that the sun moves around it, and adds eight other proofs of his proposition that "the earth can be nowhere, if not in the centre of the universe."[3]

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[1] Figuier, "Savants de la Renaissance," p. 380. Also, Flammarion, "Vie de Copernic," p. 190.

[2] The "proper authorities" in this case were the "Congregation of the Index," or cardinals having charge of the "Index Librorum Prohibitorum." Recent desperate attempts to fasten the responsibility on them as individuals seem ridiculous in view of the simple fact that their work is sanctioned by the highest Church authority, and required to be universally accepted by the Church. Three of four editions of the "Index" in my own possession declare on their title-pages that they are issued by order of the pontiff of the period, and each is prefaced by a special papal bull or letter. See specially Index of 1664, issued under order of Alexander VII., and that of 1761, under Benedict XIV. Copernicus's work was prohibited in the Index "*donec corrigatur.*" Kepler said that it ought to be worded "*donec explicetur.*" *See* Bertrand, "Fondateurs de l'Astronomie Moderne," p. 57. De Morgan, pp. 57–60, gives the corrections required by the Index of 1620. Their main aim seems to be to reduce Copernicus to the groveling level of Osiander, making of his discovery a mere hypothesis; but occasionally they require a virtual giving up of the whole Copernican doctrine, e. g., "correction" insisted upon for cap. 8, p. 6.

[3] *See* Luther's "Table Talk." Also, Melanchthon's "Initia Doctrinæ Physicæ." This

And Protestant people are not a whit behind Catholic in following out these teachings. The people of Elbing made themselves merry over a farce in which Kopernik was the main object of ridicule. The people of Nuremberg, a great Protestant centre, caused a medal to be struck, with inscriptions ridiculing the philosopher and his theory.[1]

Then was tried one piece of strategy very common formerly in battles between theologians themselves. It consists in loud shoutings that the doctrine attacked is old, outworn, and already refuted—that various distinguished gentlemen have proved it false—that it is not a living truth, but a detected lie—that, if the world listens to it, that is simply because the world is ignorant. This strategy was brought to bear on Copernicus. It was shown that his doctrine was simply a revival of the Pythagorean notion, which had been thoroughly exploded. Fromundus, in his title-page and throughout his book, delights in referring to the doctrine of the revolution of the planets around the sun, as "that Pythagorean notion." This mode of warfare was imitated by the lesser opponents, and produced, for some time, considerable effect.[2]

But the new truth could neither be laughed down nor forced down. Many minds had received it; only one tongue dared utter it. This new warrior was that strange mortal, Giordano Bruno. He was hunted from land to land, until, at last, he turns on his pursuers with fearful invectives. For this he is imprisoned six years, then burned alive and his ashes scattered to the winds. Still the new truth lived on; it could not be killed. Within ten years after the martyrdom of Bruno,[3] after a world of troubles and persecutions, the

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treatise is cited by the *Catholic World*, September, 1870. The correct title is as given above. It will be found in the "Corpus Reformatorum," ed. Bretschneider: Halle, 1846. (For the above passage *see* vol. xiii., pp. 216, 217.) Also, Lange, "Geschichte des Materialismus," vol. i., p. 217. Also, Prowe, "Ueber die Abhängigkeit des Copernicus," Thorn, 1865, p. 4. Also, note, pp. 5 and 6, where text is given in full.

[1] For treatment of Copernican ideas by the people, *see Catholic World*, as above. Fromundus, cited above, heads his sixth chapter as follows, "Scriptura Sacra Oppugnat Copernicanos," and cites from the Psalms the passage speaking of the sun which "cometh forth as a bridegroom from his chamber;" and also from Ecclesiastes, "Terra in Aeternum Stat." "Anti-Aristarchus," p. 29. Some of his titles also show his style in philosophical argument, e. g., "The wind would constantly blow from the east; we should, with great difficulty, hear sounds against such a wind" (chapter xi.); "Buildings, and the earth itself, would fly off with such a rapid motion" (chapter x.). For another of Fromundus's arguments, showing, both from theology and mathematics (with suitably-mixed theology), that the earth must be in the centre of the universe, *see* Quetelet, "Histoire des Sciences Mathématiques et Physiques," p. 170, Bruxelles, 1864.

[2] *See* title-page of Fromundus's work cited in note at bottom of p. 392; also, Melanchthon, *ubi supra*.

[3] *See* Bartholmès, "Vie de Jordano Bruno," Paris, 1846, vol. i., pp. 121 and pp. 212, *et seq.* Also Berti, "Vita di Giordano Bruno," Firenze, 1868, chapter xvi. Also Whewell, i., 294, 295. That Whewell is somewhat hasty in attributing Bruno's punishment entirely to the "Spaccio della Bestia Trionfante" will be evident, in spite of Montcula, to any one who reads the account of the persecution in Bartholmès or Berti; and, even if

truth of the doctrine of Kopernik was established by the telescope of Galileo.[1]

Herein was fulfilled one of the most touching of prophecies. Years before, the enemies of Kopernik had said to him, "If your doctrines were true, Venus would show phases like the moon." Kopernik answered: "You are right. I know not what to say; but God is good, and will in time find an answer to this objection."[2] The God-given answer came when the rude telescope of Galileo showed the phases of Venus.

On this new champion, Galileo, the attack was tremendous. The supporters of what was called "sound learning" declared his discoveries deceptions, and his announcements blasphemy. Semi-scientific professors, endeavoring to curry favor with the Church, attacked him with sham science; earnest preachers attacked him with perverted Scripture![3]

The principal weapons in the combat are worth examining. They are very easily examined. You may pick them up on any of the battle-fields of science; but on that field they were used with more effect than on almost any other. These weapons are two epithets: "Infidel" and "Atheist."

The battle-fields of science are thickly strewn with these. They have been used against almost every man who has ever done anything new for his fellow-men. The list of those who have been denounced as infidel and atheist includes almost all great men of science—general scholars, inventors, philanthropists. The deepest Christian life, the most noble Christian character have not availed to shield combatants. Christians like Isaac Newton and Pascal and John Locke and John Milton, and even Howard and Fénelon, have had these weapons hurled against them. Of all proofs of the existence of a God, those of Descartes have been wrought most thoroughly into the minds of modern men; and yet the Protestant theologians of Holland sought to bring him to torture and to death by the charge of atheism.[4]

Whewell be right, the "Spaccio" would never have been written, but for Bruno's indignation at ecclesiastical oppression. *See* Tiraboschi, vol. xi., p. 435.

[1] Delambre, "Histoire de l'Astronomie moderne," discours préliminaire, p. xiv. Also Laplace, "Système du Monde," vol. i., p. 326, and, for more careful statement, "Kepleri Opera Omnia," edit. Frisch, tom. ii., p. 464.

[2] Cantu, "Histoire Universelle," vol. xv., p 473.

[3] A very curious example of this sham science is seen in the argument, frequently used at the time, that, if the earth really moved, a stone falling from a height would fall back of the point immediately below its point of starting. This is used by Fromundus with great effect. It appears never to have occurred to him to test the matter by dropping a stone from the topmast of a ship. But the most beautiful thing of all is that Benzenburg has experimentally demonstrated just such an aberration in falling bodies as is mathematically required by the diurnal motion of the earth. *See* Jevons, "Principles of Science," vol. i., p. 453, and ii., pp. 310, 311.

[4] For curious exemplification of the way in which these weapons have been hurled, *see* lists of persons charged with "infidelity" and "atheism," in "Le Dictionnaire des Athées." Paris, An. viii. Also Lecky, "History of Rationalism," vol. ii., p. 50.

These can hardly be classed with civilized weapons. They are burning arrows. They set fire to great masses of popular prejudices; smoke rises to obscure the real questions, fire bursts forth at times to destroy the attacked party. They are poisoned weapons. They go to the hearts of loving women, they alienate dear children. They injure the man after life is ended, for they leave poisoned wounds in the hearts of those who loved him best—fears for his eternal happiness—dread of the divine displeasure.

Of course, in these days, these weapons, though often effective in disturbing good men, and in scaring good women, are somewhat blunted. Indeed, they not unfrequently injure assailants more than assailed; so it was not in the days of Galileo. These weapons were then in all their sharpness and venom.

The first champion who appears against him is Bellarmin, one of the greatest of theologians, and one of the poorest of scientists. He was earnest, sincere, learned, but made the fearful mistake for the world, of applying to science, direct, literal interpretation of Scripture.[1]

The weapons which men of Bellarmin's stamp used were theological. They held up before the world the dreadful consequences which must result to Christian theology were the doctrine to prevail that the heavenly bodies revolve about the sun, and not about the earth. Their most tremendous theologic engine against Galileo was the idea that his pretended discovery vitiated the whole Christian plan of salvation. Father Le Gazrée declared that it "cast suspicion on the doctrine of the Incarnation." Others declared that it "upset the whole basis of theology; that if the earth is a planet, and one among several planets, it cannot be that any such great things have been done especially for it, as the Christian doctrine teaches. If there are other planets, since God makes nothing in vain, they must be inhabited; but how can these inhabitants be descended from Adam? How can they trace back their origin to Noah's ark? How can they have been redeemed by the Saviour?"[2]

Nor was this argument confined to the theologians of the Roman Church; Melanchthon, Protestant as he was, had already used it in his attacks upon the ideas of Copernicus and his school.[3]

In addition to this prodigious engine of war, there was kept up a terrific fire of smaller artillery in the shape of texts and scriptural extracts. Some samples of these weapons may be interesting.

When Galileo had discovered the four satellites of Jupiter,[4] the whole thing was denounced as impossible and impious. It was argued that the Bible clearly showed by all applicable types, that there could be only seven planets; that this was proved by the seven golden candlesticks of the Apocalypse, by the seven-branched candlestick of the Tabernacle, and by the seven churches of Asia.[1]

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[1] For Bellarmin's view *see* Quinet, "Jesuits," vol. ii., p. 189. For other objectors and objections, *see* Libri, "Histoire des Sciences Mathématiques en Italie," vol. iv., pp. 233, 234; also, "Private Life of Galileo," compiled from his correspondence and that of his eldest daughter, Boston, 1870 (an excellent little book).

[2] *See* Trouessart, cited in Flammarion, "Mondes Imaginaires et Réels," sixième édition, pp. 315, 316.

[3] "Initia Doctrinæ Physicæ," pp. 220, 221.

[4] *See* Delambre as to the discovery of the satellites of Jupiter being the turning-point

In a letter to his friend Renieri, Galileo gives a sketch of the dealings of the Inquisition with him. He says: "The Father Commissary, Lancio, was zealous to have me make amends for the scandal I had caused in sustaining the idea of the movement of the earth. To all my mathematical and other reasons he responded nothing but the words of Scripture, '*Terra autem in æternum stat.*'"[2]

It was declared that the doctrine was proved false by the standing still of the sun for Joshua; by the declarations that "the foundations of the earth are fixed so firm that they cannot be moved," and that the sun "runneth about from one end of heaven to the other."[3]

The Dominican father, Caccini, preached a sermon from the text, "Ye men of Galilee, why stand ye gazing up into heaven?" and this wretched pun was the first of a series of sharper weapons, for before Caccini finishes he insists that "geometry is of the devil," and that "mathematicians should be banished as the authors of all heresies."[4]

For the final assault, the park of heavy artillery was at last wheeled into place. You see it on all the scientific battle-fields. It consists of general denunciation, and Father Melchior Inchofer, of the Jesuits, brought his artillery to bear well on Galileo with this declaration: that the opinion of the earth's motion is, of all heresies, the most abominable, the most pernicious, the most scandalous; that the immobility of the earth is thrice sacred; that argument against the immortality of the soul, the Creator, the incarnation, etc., should be tolerated sooner than an argument to prove that the earth moves.[5]

In vain did Galileo try to prove the existence of satellites by showing them to the doubters through his telescope. They either declared it impious to look, or, if they did see them, denounced them as illusions from the devil. Good Father Clavius declared that "to see satellites of Jupiter, men had to make an instrument which would create them."[6]

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with the heliocentric doctrine. As to its effects on Bacon, *see* Jevons, "Principles of Science," vol. ii., p. 298.

[1] For argument drawn from the candlestick and seven churches, *see* Delambre.

[2] For Galileo's letter to Renieri, *see* Cantu, "Hist. Universelle," Paris, 1855, xv., p. 477, note.

[3] Cantu, "Histoire Universelle," vol. xv., p. 478.

[4] For Caccini's attack, *see* Delambre, "Hist. de l'Astron.," disc. prélim., p. xxii., also Libri, "Hist. des Sciences Math.," vol. iv., p. 232.

[5] *See* Inchofer's "Tractatus Syllepticus," cited in Galileo's letter to Deodati, July 28, 1634.

[6] Libri, vol. iv., p. 211. De Morgan, "Paradoxes," p. 26, for account of Father Clavius. It is interesting to know that Clavius, in his last years, acknowledged that "the whole system of the heavens is broken down, and must be mended."

In vain did Galileo try to protect himself by his famous letter to the duchess, in which he insisted that theological reasoning should not be applied to science. The rest of the story the world knows by heart; none of the recent attempts have succeeded in mystifying it. The whole world will remember forever how Galileo was subjected certainly to indignity and imprisonment equivalent to physical torture;[1] how he was at last forced to pronounce publicly, and on his knees, his recantation as follows: "I, Galileo, being in my seventieth year, being a prisoner and on my knees, and before your eminences, having before my eyes the Holy Gospel, which I touch with my hands, abjure, curse, and detest, the error and heresy of the movement of the earth."[2]

He was vanquished indeed, for he had been forced, in the face of all coming ages, to perjure himself. His books were condemned, his friends not allowed to erect a monument over his bones. To all appearance his work was overthrown.

Do not understand me here as casting blame on the Roman Church as such. It must, in fairness, be said that some of its best men tried to stop this great mistake; even the pope himself would have been glad to stop it; but the current was too strong.[3] The whole of the civilized world was at fault, Protestant as well as Catholic, and not any particular part of it. It was not the fault of religion, it was the fault of the short-sighted views which narrow-minded, loud-voiced men are ever prone to mix in with religion, and to insist *is* religion.[4]

Were there time, I would refer at length to some of the modern mystifications of the history of Galileo. One of the latest seems to have for its groundwork the theory that Galileo was condemned for a breach of good taste and etiquette. But those who make this defense make the matter infinitely worse for those who committed the great wrong. They deprive it of its only palliation, mistaken conscientiousness.[1]

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[1] It is not probable that torture in the ordinary sense was administered to Galileo. *See* Th. Martin, "Vie de Galilée," for a fair summing up of the case.

[2] For text of the abjuration, *see* "Private Life of Galileo," Appendix. As to the time when the decree of condemnation was repealed, various authorities differ. Artaud, p. 307, cited in an apologetic article in *Dublin Review*, September, 1865, says that Galileo's famous dialogue was published in 1744, at Padua, entire, and with the usual approbations. The same article also declares that in 1818 the ecclesiastical decrees were repealed by Pius VII., in full Consistory. Whewell says that Galileo's writings, after some opposition, were expunged from the "Index Expurgatorius," in 1818. Cantu, an authority rather favorable to the Church, says that Copernicus's work remained on the "Index" as late as 1835. Cantu, "Histoire Universelle," vol., xv., p. 483.

[3] For Baronius's remark *see* De Morgan, p. 26. Also Whewell, vol. i., p. 394.

[4] For an exceedingly striking statement, by a Roman Catholic historian of genius, as to popular demand for persecution, and the pressure of the lower strata, in ecclesiastical organizations, for cruel measures, *see* Balmès, "Le Protestantisme comparé au Catholicisme," etc., 4th ed., Paris, 1855, vol. ii. Archbishop Spaulding has something of the same sort in his Miscellanies. L'Epinois, "Galilée," p. 22, *et seq.*, stretches this as far as possible, to save the reputation of the Church in the Galileo matter.

Nor was this the worst loss to the earth.

There was then in Europe one of the greatest thinkers ever given to mankind. Mistaken though many of his theories were, they were fruitful in truths. The man was Réné Descartes. The scientific warriors had stirred new life in him, and he was working over and summing up in his mighty mind all the researches of his time. The result must make an epoch in the history of man. His aim was to combine all knowledge and thought into a "Treatise on the World." His earnestness he proved by the eleven years which he gave to the study of anatomy alone. Petty persecution he had met often, but the fate of Galileo robbed him of all hope, of all energy. The battle seemed lost. He gave up his great plan forever.[2]

But champions pressed on. Campanella, full of vagaries as he was, wrote his "Apologia pro Galileo," though for that and other heresies, religious and political, he seven times underwent torture.[3]

And Kepler comes. He leads science on to greater victories. He throws out the minor errors of Kopernik. He thinks and speaks as one inspired. His battle is severe. He is sometimes abused, sometimes ridiculed, sometimes imprisoned. Protestants in Styria and at Tübingen, Catholics at Rome press upon him,[1] but Newton, Huyghens and the other great leaders follow, and to science remains the victory.

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[1] *See Dublin Review*, as above. Whewell, vol. i., 393. Citation from Marini: "Galileo was punished for trifling with the authorities to which he refused to submit, and was punished for obstinate contumacy, not heresy." The sufficient answer to all this is that the words of the inflexible sentence designating the condemned books are: "*Libri omnes qui affirmant telluris motum.*" *See* Bertrand, p. 59. It has also been urged that "Galileo was punished not for his opinion, but for basing it on Scripture." The answer to this may be found in the Roman Index of 1704, in which are noted for condemnation "*Libri omnes docentes mobilitatem terræ et inmobilitatem solis.*" For the way in which, when it was found convenient in argument, Church apologists insisted that it *was* "the Supreme Chief of the Church, by a pontifical decree, and not certain cardinals," who condemned Galileo and his doctrine, *see* Father Gazrée's letter to Gassendi in Flammarion, "Pluralité des Mondes," p. 427. For the way in which, when necessary, Church apologists asserted the very contrary of this, declaring that "it was issued in a doctrinal decree of the Congregation of the Index, and *not* as the Holy Father's teaching," *see Dublin Review*, September, 1865. And for the most astounding attempt of all, to take the blame off the shoulders of both pope and cardinals, and place it upon the Almighty, see the following words of the article above cited: "But it may well be doubted whether the Church did retard the progress of scientific truth. What retarded it was the circumstance that God has thought fit to express many texts of Scripture in words which have every appearance of denying the earth's motion. But it is God who did this, not the Church; and, moreover, since he thought fit so to act as to retard the progress of scientific truth, it would be little to her discredit even if it were true that she had followed his example."—*Dublin Review*, September, 1865, p. 419. For the best summary of the various attempts, and for replies to them in a spirit of judicial fairness, *see* Th. Martin, "Vie de Galilée." This is probably the best book ever written on the Galileo question. The bibliography at the close is very valuable.

[2] Humboldt, "Cosmos," London, 1851, vol. iii., p. 21. Also Lange, "Geschichte des Materialismus," vol. i., p. 222, where the letters of Descartes are given, showing his despair, and the giving up of his best thoughts and works to preserve peace with the Church. Also Jolly, "Hist. du Mouvement Intellectuel au XVI^e Siècle," vol. i., p. 390.

[3] Libri, pp. 149, *et seq.*

And yet the war did not wholly end. During the seventeenth century, in all France, no one dared openly teach the Copernican theory, and Cassini, the great astronomer, never declared it.[2] In 1672, Father Riccioli, a Jesuit, declared that there were precisely forty-nine arguments for the Copernican theory and seventy-seven against it; so that there remained twenty-eight reasons for preferring the orthodox theory.[3] Toward the end of the seventeenth century also, even Bossuet, the "eagle of Meaux," among the loftiest of religious thinkers, declared for the Ptolemaic theory as the Scriptural theory,[4] and in 1746 Boscovich, the great mathematician of the Jesuits, used these words: "As for me, full of respect for the Holy Scriptures and the decree of the Holy Inquisition, I regard the earth as immovable; nevertheless, for simplicity in explanation, I will argue as if the earth moves, for it is proved that of the two hypotheses the appearances favor that idea."[5]

The Protestantism of England was no better. In 1772 sailed the famous English expedition for scientific discovery under Cook. The greatest by far of all the scientific authorities chosen to accompany it was Dr. Priestley. Sir Joseph Banks had especially invited him; but the clergy of Oxford and Cambridge intervened. Priestley was considered unsound in his views of the Trinity; it was declared that this would vitiate his astronomical observations; he was rejected and the expedition crippled.[6]

Nor has the opposition failed even in our own time. On the 5th of May, 1826, a great multitude assembled at Thorn to celebrate the three hundredth anniversary of Kopernik, and to unveil Thorwaldsen's statue of him.

Kopernik had lived a pious, Christian life. He was well known for unostentatious Christian charity. With his religious belief no fault had ever been found. He was a canon of the church of Frauenberg, and over his grave had been written the most touching of Christian epitaphs.

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[1] Fromundus, speaking of Kepler's explanation, says: "Vix teneo ebullientem risum." It is almost equal to the *New York Church Journal*, speaking of John Stuart Mill as "that small sciolist," and of the preface to Dr. Draper's recent work as "chippering." How a journal generally so fair in its treatment of such subjects can condescend to use such weapons is one of the wonders of modern journalism. For Protestant persecution of Kepler, *see* vol. i., p. 392.

[2] For Cassini's position, *see* Henri Martin, "Hist. de France," vol. xiii., p. 175.

[3] Daunou, "Études Historiques," vol. ii., p. 439.

[4] Bossuet, *see* Bertrand, p. 41.

[5] Boscovich. This was in 1746, but in 1785 Boscovich seemed to feel his position in view of history, and apologized abjectly. Bertrand, pp. 60, 61. *See* also Whewell's notice of Le Sueur and Jacquier's introduction to their edition of Newton's "Principia." For the most recent proofs of the Copernican theory, by discoveries of Bunsen, Bischoff, Benzenburg, and others, *see* Jevons, "Principles of Science."

[6] *See* Weld, "History of the Royal Society," vol. ii., p. 56, for the facts and the admirable letter of Priestley upon this rejection.

Naturally, then, the people expected a religious service. All was understood to be arranged for it. The procession marched to the church and waited. The hour passed, no priest appeared; none could be induced to appear. Kopernik, simple, charitable, pious, one of the noblest gifts of God to the service of religion as well as science, was still held to be a reprobate. Seven years after that, his book was still standing on the "Index of Books prohibited to Christians."[1]

Nor has this warfare against dead champions of science been carried on only by the older Church.

On the 10th of May, 1859, was buried Alexander von Humboldt. His labors were among the greatest glories of the century, and his funeral one of the most imposing that Berlin had ever seen: among those who honored themselves by their presence was the prince regent—the present emperor. But of the clergy it was observed that none were present save the officiating clergyman and a few regarded as unorthodox.[2]

Nor have attempts to renew the battle been wanting in these latter days. The attempt in the Church of England, in 1864, to fetter Science—which was brought to ridicule by Herschel, Bowring, and De Morgan; the Lutheran assemblage at Berlin, in 1868, to protest against "science falsely so called," in the midst of which stood Pastor Knak denouncing the Copernican theory; the "Syllabus," the greatest mistake of the Roman Church, are all examples of this.[3]

And now, what has been won by either party in this long and terrible war? The party which would subordinate the methods and aims of science to those of theology, though in general obedient to deep convictions, had given to Christianity a series of the worst blows it had ever received. They had made large numbers of the best men in Europe hate it. Why did Ricetto and Bruno and Vanini, when the crucifix was presented to them in their hours of martyrdom, turn from that blessed image with loathing?[4] Simply because Christianity had been made to them identical with the most horrible oppression of the mind.

Worse than that, the well-meaning defenders of the faith had wrought into the very fibre of the European heart that most unfortunate of all ideas, the idea that there is a necessary antagonism between science and religion. Like the landsman who lashes himself to the anchor of the sinking ship, they had attached the great fundamental doctrines of Christianity, by the strongest cords of logic which they could spin, to these mistaken ideas in science, and the advance of knowledge had wellnigh engulfed them.

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[1] Bertrand, "Fondateurs de l'Astron. Mod.," p. 61. Flammarion, "Vie de Copernic," chap. ix.

[2] Bruhns and Lassell, "Life of Humboldt," London, 1873, vol. ii., p. 411.

[3] For the very amusing details of the English attempt, and of the way in which it was met, *see* De Morgan, "Paradoxes," p. 42. For Pastor Knak and his associates, *see Revue des Deux Mondes*, 1868.

[4] For a striking account, gathered from eye-witnesses, of this frightful scene at the execution of Bruno, *see* letter of Scioppius in appendix to vol. iv. of Libri, "Hist. des Mathématiques."

On the other hand, what had science done for religion? Simply this: Kopernik, escaping persecution only by death; Giordano Bruno, burned alive as a monster of impiety; Galileo, imprisoned and humiliated as the worst of misbelievers; Kepler, hunted alike by Protestant and Catholic, had given to religion great new foundations, great new, ennobling conceptions, a great new revelation of the might of God.

Under the old system we have that princely astronomer, Alfonso of Castile, seeing the poverty of the Ptolemaic system, yet knowing no other, startling Europe with the blasphemy that if he had been present at creation he could have suggested a better ordering of the heavenly bodies. Under the new system you have Kepler, filled with a religious spirit, exclaiming, "I do think the thoughts of God."[1] The difference in religious spirit between these two men marks the conquest made in this, even by science, for religion. But we cannot leave the subject of astronomy without noticing the most recent warfare. Especially interesting is it because at one period the battle seemed utterly lost, and then was won beautifully, thoroughly, by a legitimate advance in scientific knowledge. I speak of the Nebular Hypothesis.

The sacred writings of the Jews which we have inherited speak clearly of the creation of the heavenly bodies by direct intervention, and for the convenience of the earth. This was the view of the Fathers of the Church, and was transmitted through the great doctors in theology.

More than that, it was crystallized in art. So have I seen, over the portal of the Cathedral of Freiburg, a representation of the Almighty making and placing numbers of wafer-like suns, moons, and stars; and at the centre of all, platter-like and largest of all, the earth.[2] The lines on the Creator's face show that he is obliged to contrive; the lines of his muscles show that he is obliged to toil. Naturally, then, did sculptors and painters of the mediæval and early modern period represent the Almighty as weary after labor, and enjoying dignified repose.

These ideas, more or less gross in their accompaniments, passed into the popular creed of the modern period.

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[1] As a pendant to this ejaculation of Kepler may be cited those wondrous words of Linnæus: "Deum omnipotentem a tergo transeuntem vidi et obstupui."

[2] For papal bulls representing the earth as a flat disk, *see* Daunou, "Études Historiques," vol. ii., p. 421.

But about the close of the last century, Bruno having guessed the fundamental fact of the nebular hypothesis, and Kant having reasoned out its foundation idea, Laplace developed it, showing the reason for supposing that our own solar system, in its sun, planets, satellites, with their various motions, distances, and magnitudes, is a natural result of the diminishing heat of a nebulous mass—a result obeying natural laws.

There was an outcry at once against the "atheism" of the scheme. The war raged fiercely. Laplace claimed that there were in the heavens many nebulous patches yet in the gaseous form, and pointed them out. He showed by laws of physics and mathematical demonstration that his hypothesis accounted in a most striking manner for the great body of facts, and, despite clamor, was gaining ground, when the improved telescopes resolved some of the patches of nebulous matter into multitudes of stars.

The opponents of the nebular hypothesis were overjoyed. They sang pæans to astronomy, because, as they said, it had proved the truth of Scripture.

They had jumped to the conclusion that all nebulæ must be alike—that if some are made up of systems of stars all must be so made up; that none can be masses of attenuated gaseous matter, because some are not.

Science, for a time, halted. The accepted doctrine became this—that the only reason why all the nebulæ are not resolved into distinct stars is, because our telescopes are not sufficiently powerful.

But in time came that wonderful discovery of the spectroscope and spectrum analysis, and this was supplemented by Fraunhofer's discovery that the spectrum of an ignited gaseous body is discontinuous, with interrupting lines; and this, in 1846, by Draper's discovery that the spectrum of an ignited solid is continuous, with no interrupting lines. And now the spectroscope was turned upon the nebulæ and about one-third of them were found to be gaseous.

Again the nebular hypothesis comes forth stronger than ever. The beautiful experiment of Plateau on the rotation of a fluid globe comes in to strengthen if not to confirm it. But what was likely to be lost in this? Simply a poor conception of the universe. What to be gained? A far more worthy idea of that vast power which works in the universe, in all things by law, and in none by caprice.[1]

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[1] For Bruno's conjecture (in 1591), *see* Jevons, vol. ii., p. 299. For Kant's part in the nebular hypothesis, *see* Lange, "Geschichte des Materialismus," vol. i., p. 266. For value of Plateau's beautiful experiment very cautiously estimated, *see* W. Stanley Jevons, "Principles of Science," London, 1874, vol. ii., p. 36. Also Elisée Réclus, "The Earth," translated by Woodward, vol. i., pp. 14–18, for an estimate still more careful. For a general account of discoveries of nature of nebulæ by spectroscope, *see* Draper, "Conflict between Religion and Science." For a careful discussion regarding the spectra of solid, liquid, and gaseous bodies, *see* Schellen, "Spectrum Analysis," pp. 100, *et seq.* For a very thorough discussion of the bearings of discoveries made by spectrum analysis upon the

The great series of battles to which I next turn with you were fought on those fields occupied by such sciences as chemistry and natural philosophy.

Even before those sciences were out of their childhood, while yet they were tottering mainly toward childish objects and by childish steps, the champions of that same old mistaken conception of rigid scriptural interpretation began the war. The catalogue of chemists and physicists persecuted or thwarted would fill volumes; from them I will select just three as representative men.

First of these I take Albert of Bollstadt, better known in the middle ages as Albert the Great. In the thirteenth century he stands forth as the greatest scholar in Germany. Fettered though he was by the absurd methods of his time, led astray as he was by the scholastic spirit, he has conceived ideas of better methods and aims. His eye pierces the mists of scholasticism, he sees the light and draws the world toward it. He stands among the great pioneers of modern physical and natural science. He gives foundations to botany and chemistry, and Humboldt finds in his works the germ of the comprehensive science of physical geography.[1]

The conscience of the time, acting as it supposed in defense of religion, brought out a missile which it hurled with deadly effect. You see those mediæval scientific battle-fields strewn with such: it was the charge of sorcery, of unlawful compact with the devil.

This missile was effective. You find it used against every great investigator of Nature in those times and for centuries after. The list of great men charged with magic, as given by Naudé, is astounding. It includes every man of real mark, and the most thoughtful of the popes, Sylvester II. (Gerbert), stands in the midst of them. It seemed to be the received idea that, as soon as a man conceived a love to study the works of God, his first step must be a league with the devil.[2]

This missile was hurled against Albert. He was condemned by the great founder of the Dominican order himself. But more terrible weapons than this missile were added to it, to make it effective. Many an obscure chemist paid a terrible penalty for wishing to be wiser than his time; but I pass to the greater martyrs.

I name, next, Roger Bacon. His life and work seem until recent-

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nebular hypothesis, ibid., pp. 532–537. For a presentation of the difficulties yet unsolved, *see* article by Plummer, in London *Popular Science Review* for January, 1875. For excellent short summary of recent observations and thought on this subject, *see* T. Sterry Hunt, "Address at the Priestley Centennial," pp. 7, 8. For an interesting modification of this hypothesis, *see* Proctor's recent writings.

[1] "Il était aussi très-habile dans les arts mécaniques, ce que le fit soupçonner d'être sorcier."—Sprengel, "Histoire de la Médecine," vol. ii., p. 389.

[2] For the charge of magic against scholars and others, *see* Naudé, "Apologie pour les grands hommes accusés de Magie," *passim*. Also, Maury, "Hist. de la Magie," troisième édit., pp. 214, 215. Also Cuvier, "Hist. des Sciences Naturelles," vol. i., p. 396.

ly to have been generally misunderstood. He has been ranked as a superstitious alchemist who stumbled upon some inventions; but more recent investigation has revealed him to be one of the great masters in human progress.

The advance of sound historical judgment seems likely to reverse the positions of the two who bear the name of Bacon. Bacon of the chancellorship and the "Novum Organon" seems to wane. Bacon of the prison-cell and the "Opus Majus" seems to grow brighter.[1]

Roger Bacon's work, as it is now revealed to us, was wonderful. He wrought with power in philosophy and in all sciences, and his knowledge was sound and exact. By him, more than by any other man of the middle ages, was the world put on the most fruitful paths of science—the paths which have led to the most precious inventions. Clocks, lenses, burning specula, telescopes, were given by him to the world, directly or indirectly. In his writings are found formulæ for extracting phosphorus, manganese, and bismuth. It is even claimed that he investigated the power of steam. He seems to have very nearly reached also some of the principal doctrines of modern chemistry. His theory of investigation was even greater than these vast results. In an age when metaphysical subtilizing was alone thought to give the title of scholar, he insisted on *real* reasoning and the aid of natural science by mathematics. In an age when experimenting was sure to cost a man his reputation and was likely to cost him his life, he insisted on experiment and braved all its risks. Few greater men have lived. As we read the sketch given by Whewell of Bacon's process of reasoning regarding the refraction of light, he seems fairly inspired.

On this man came the brunt of the battle. The most conscientious men of his time thought it their duty to fight him, and they did it too well. It was not that he disbelieved in Christianity, *that* was never charged against him. His orthodoxy was perfect. He was attacked and condemned, in the words of his opponents, "*propter quasdam novitates suspectas.*"

He was attacked, first of all, with that goodly old missile, which, with the epithets "infidel" and "atheist," has decided the fate of so many battles—the charge of magic and compact with Satan.

He defended himself with a most unfortunate weapon—a weapon which exploded in his hands and injured him more than the enemy, for he argued against the idea of compacts with Satan, and showed that much which is ascribed to demons results from natural means. This added fuel to the flame. To limit the power of Satan was deemed hardly less impious than to limit the power of God.

The most powerful protectors availed him little. His friend Guy

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[1] For a very contemptuous statement of Lord Bacon's claim to his position as a philosopher, *see* Lange, "Geschichte des Materialismus," Leipsic, 1874, vol. i., p. 219. *See* also Jevons, "Principles of Science," London, 1874, vol. ii., p. 298.

Foulkes having been made pope, Bacon was for a time shielded, but the fury of the enemy was too strong. In an unpublished letter, Blackstone declares that when, on one occasion, Bacon was about to perform a few experiments for some friends, all Oxford was in an uproar. It was believed that Satan was let loose. Everywhere were priests, fellows, and students rushing about, their garments streaming in the wind, and everywhere resounded the cry, "Down with the conjurer!" and this cry "Down with the conjurer" resounded from cell to cell and hall to hall.[1]

But the attack took a shape far more terrible. The two great religious orders, Franciscan and Dominican, vied with each other in fighting the new thought in chemistry and philosophy. St. Dominic, sincere as he was, solemnly condemned research by experiment and observation. The general of the Franciscan order took similar grounds.

In 1243 the Dominicans solemnly interdicted every member of their order from the study of medicine and natural philosophy; and, in 1287, this interdiction was extended to the study of chemistry.[2]

Another weapon began to be used upon the battle-fields of that time with much effect. The Arabs had made noble discoveries in science. Averroes had, among many, divided the honors with St. Thomas Aquinas. These facts gave the new missile. It was the epithet "Mahometan." This, too, was flung with effect at Bacon.[3]

Bacon was at last conquered. He was imprisoned for fourteen years. At the age of eighty years he was released from prison, but death alone took him beyond the reach of his enemies. How deeply the struggle had racked his mind may be gathered from that last afflicting declaration of his: "Would that I had not given myself so much trouble for the love of science!"

Sad is it to think of what this great man might have given to the world had the world not refused the gift. He held the key of treasures which would have freed mankind from ages of error and misery. With his discoveries as a basis, with his method as a guide, what might not the world have gained! Nor was the wrong done to that age alone. It was done to this age also. The nineteenth century was robbed at the same time with the thirteenth. But for that interference with science, this nineteenth century would, without doubt, be enjoying discoveries which will not be reached before the twentieth century. Thousands of precious lives shall be lost in this century, tens of thousands shall suffer discomfort, privation, sickness, poverty, ignorance, for lack of discoveries and methods which, but for this mistaken religious fight against Bacon and his compeers, would now be blessing the earth.

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[1] Whewell, vol. i., pp. 367, 368. Draper, p. 438. Saisset, "Descartes et ses Précurseurs," deuxième édition, pp. 397, *et seq.* Nourrisson, "Progrès de la pensée humaine," pp. 271, 272. Sprengel, "Histoire de la Médecine," Paris, 1865, vol. ii., p. 397. Cuvier, "Histoire des Sciences Naturelles," vol. i., p. 417. As to Bacon's orthodoxy, *see* Saisset, pp. 53, 55. For special examination of causes of Bacon's condemnation, *see* Waddington, cited by Saisset, p. 14. On Bacon as a sorcerer, *see* Featherstonaugh's article in *North American Review*. For a good example of the danger of denying full power of Satan, even in much more recent times, and in a Protestant country, *see* account of treatment of Bekker's "Monde Enchanté" by the theologians of Holland, in Nisard, "Histoire des Livres Populaires," vol. i., pp. 172, 173.

[2] Henri Martin, "Hist. de France," vol. iv., p. 283.

[3] On Bacon as a "Mahometan," *see* Saisset, p. 17.

In 1868 and 1869, sixty thousand children died in England and in Wales of scarlet fever; probably nearly as many died in this country. Had not Bacon been hindered we should have had in our hands, by this time, the means to save two-thirds of these victims, and the same is true of typhoid, typhus, and that great class of diseases of whose physical causes Science is just beginning to get an inkling. Put together all the efforts of all the atheists who have ever lived, and they have not done so much harm to Christianity and the world as has been done by the narrow-minded, conscientious men who persecuted Roger Bacon.[1]

Roger Bacon was vanquished. For ages the champions of science were crippled; but the "good fight" was carried on. The Church itself furnishes heroes of science. Antonio de Dominis relinquishes his archbishopric of Spalatro, investigates the phenomena of light, and dies in the clutches of the Inquisition.[2]

Pierre de la Ramée stands up against Aristotelianism at Paris. A royal edict, sought by the Church, stopped his teaching, and the massacre of St. Bartholomew ended his life.

Somewhat later, John Baptist Porta began his investigations. Despite many absurdities, his work was most fruitful. His book on meteorology was the first in which sound ideas were broached. His researches in optics gave the world the camera obscura, and, possibly, the telescope. He encountered the same old policy of conscientious men. The society founded by him for physical research, "I Secreti," was broken up, and he was summoned to Rome and censured.[3]

In 1624, some young chemists of Paris having taught the experimental method, and cut loose from Aristotle, the Faculty of Theology besets the Parliament of Paris, and the Parliament prohibits this new chemical teaching under penalty of death.[4]

The war went on in Italy. In 1657 occurred the first sitting of the *Accademia del Cimento*, at Florence, under the presidency of Prince Leopold dei Medici. This Academy promised great things for science. It was open to all talent. Its only fundamental law was "the repudiation of any favorite system or sect of philosophy, and the obligation to investigate Nature by the pure light of experiment."

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[1] For proofs that the world is steadily working toward great discoveries as to the cause and prevention of zymotic diseases and of their propagation, *see* Beale's "Disease Germe," Baldwin Latham's "Sanitary Engineering," Michel Lévy, "Traité d'Hygiène Publique et Privée," Paris, 1869. And for very thorough summaries, *see* President Barnard's paper read before Sanitary Congress in New York, 1874, and Dr. J. C. Dalton's "Anniversary Discourse, on the Origin and Propagation of Disease," New York, 1874.

[2] Antonio de Dominis, *see* Montucla, "Hist. des Mathématiques," vol. i., p. 705. Humboldt, "Cosmos." Libri, vol. iv., pp. 145, *et seq.*

[3] Sprengel, "Hist. de la Médecine, iii., p. 239. Also Musset-Parthay.

[4] Henri Martin, "Histoire de France," vol. xii., pp. 14, 15.

The new Academy entered into scientific investigations with energy. Borelli in mathematics, Redi in natural history, and many others, pushed on the boundaries of knowledge. Heat, light, magnetism, electricity, projectiles, digestion, the incompressibility of water, were studied by the right method and with results that enriched the world.

The Academy was a fortress of science, and siege was soon laid to it. The votaries of scholastic learning denounced it as irreligious. Quarrels were fomented. Leopold was bribed with a cardinal's hat and drawn away to Rome; and, after ten years of beleaguering, the fortress fell: Borelli was left a beggar; Oliva killed himself in despair.[1]

From the dismissal of the scientific professors from the University of Salamanca by Ferdinand VII. of Spain, in the beginning of this century, down to sundry dealings with scientific men in our own land and time, we see the same war continued.

Joseph de Maistre, uttering his hatred of physical sciences, declaring that man has paid too dearly for them, asserting that they must be subjected to theology, likening them to fire—good when confined but fearful when scattered about—this brilliant thinker has been the centre of a great opposing camp in our own time—an army of good men who cannot relinquish the idea that the Bible is a text-book of science.

[*To be continued.*]

NATURAL HISTORY OF THE KANGAROO.

By ST. GEORGE MIVART, F.R.S.

THE kangaroos have now become familiar objects to all who visit our Zoölogical Gardens, or who are familiar with any considerable zoölogical museum.

Their general external form, when seen in the attitude they habitually assume when grazing (with their front limbs touching the ground), may have recalled to mind, more or less, the appearance presented by some hornless deer. Their chief mode of locomotion (that jumping action necessitated by the great length of the hind-limbs) must be familiar to all who have observed them living, and also, very probably, the singular mode in which the young are carried in a pouch of skin in the front of the belly of the mother.

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[1] Napier, "Florentine History," vol. v., p. 485. Tiraboschi, "Storia della Literatura." Henri Martin, "Histoire de France." Jevons, "Principles of Science," vol. ii., pp. 36–40. Libri, in his "Essai sur Galilée," p. 37, says that Oliva was summoned to Rome and so tortured by the Inquisition that, to escape further cruelty, he ended his life by throwing himself from a window. For closing, by church authority, of the Academy, "I Secreti," instituted for scientific investigation at an earlier period, *see* reference to Porta in this article. On Porta, *see* Sprengel, "Histoire de la Médecine," vol. iii., p. 239.

But "What is a kangaroo?" The question will raise in the minds of those who are not naturalists the image of some familiar circumstances like those just referred to. But such image will afford no real answer to the question. To arrive at *such* an answer it is necessary to estimate correctly in what relation the kangaroo stands to other

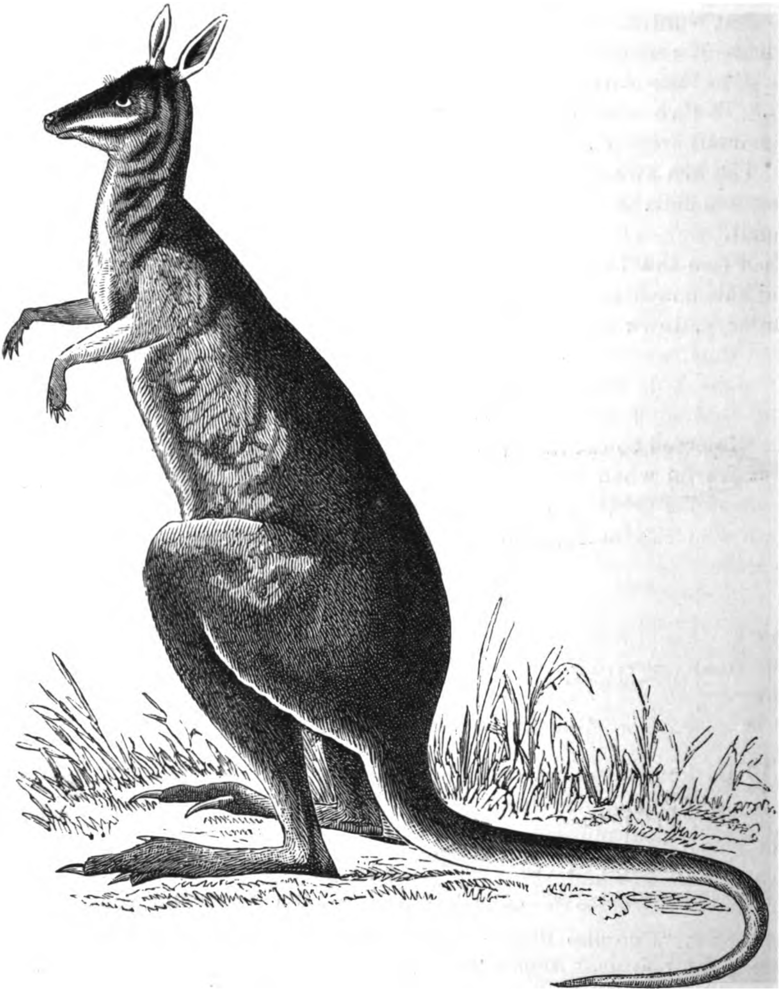

FIG. 1.—KANGAROO (*Macropus*).

animals—its place in the scale of animated beings—as also its relations to space and time; that is, its distribution over the earth's surface to-day, in connection with that of other animals more or less like it, and its relation to the past life of this planet, in connection with similar relations of animals also more or less like it. In other words, to understand what a kangaroo is, we must understand its zoölogical, geographical, and geological conditions. And my task in this paper is to make these conditions as clear as I can, and so to enable the reader to really answer the question, "What is a kangaroo?"

But before proceeding to these matters, let us look at our kangaroo a little closer, and learn something of its structure, habits, and history, so as to have some clear conceptions of the kangaroo considered by itself, before considering its relations with the universe (animate and inanimate) about it.

The kangaroo (Fig. 1) is a quadruped, with very long hind-limbs and a long and rather thick tail. Its head possesses rather a long muzzle, somewhat like that of a deer, with a pair of rather long ears. Each fore-paw has five toes, urnished with claws. Each hind-limb has but two large and conspicuous toes, the inner one of which is much the larger, and bears a very long and strong claw (Fig. 2). On the inner side of this is what appears to be a very minute toe, furnished with two small claws. An examination of the bones of the foot shows us, however, that it really consists of two very slender toes united together in a common fold of skin. These toes answer to the second and third toes of our own foot, and there is no representative of our great-toe—not even that part of it which is inclosed in the substance of our foot, called the *inner metatarsal bone*. Two other points are specially noteworthy in the skeleton. The first of these is that the pelvis (or bony girdle to which the hind-limbs are articulated, and by which they are connected with the back-bone) has two elongated bones extending upward from its superior margin in front (Fig. 4, *a*). These are called marsupial bones, and lie within the flesh of the front of the animal's belly. The other point is that the lower, hinder portion of each side of the lower jaw (which portion is technically called the "*angle*") is bent inward, or "inflected," and not continued directly backward in the same plane as the rest of the lower jaw.

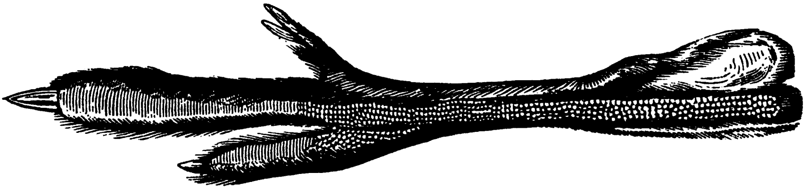

FIG. 2.—FOOT OF KANGAROO.

A certain muscle, called the cremaster muscle, is attached to each marsupial bone, and thence stretches itself over the inner or deep surface of the adjacent mammary gland or "breast," which is situated low down, and not in the breast at all.

The kangaroo's teeth consist of three on each side in the front of the mouth, and one on each side below. These eight teeth are what are called incisors. At the back of the mouth there are five grinding-teeth on each side above and five below, and between the upper grinders and incisors another pointed tooth, called a canine, may or may not be interposed. Such a set of teeth is indicated by the following formula, where I stands for incisors, C for canines, and M for grinding-teeth or "molars." The number above each line indicates the teeth of each denomination which exist on one side of the upper jaw, and the lower number those of the lower jaw:

$$I\ \frac{3}{1}\ C\ \frac{0}{0}\ \text{or}\ \frac{1}{0}\ M\ \frac{5}{5} = \frac{9}{6}\ \text{or}\ \frac{8}{6}$$

The total number of incisor teeth of *both* sides of each jaw may therefore be expressed thus: I $\frac{6}{2}$.

Such is the general structure of an adult kangaroo. At birth it is strangely different from what it ultimately becomes.

It is customary to speak of the human infant as exceptionally helpless at birth and after it, but it is at once capable of vigorous sucking, and very early learns to seek the nipple. The great kangaroo, standing some six feet high, is at birth scarcely more than an inch long, with delicate naked skin, and looking like part of an earthworm. But, in such feeble and imperfectly developed condition, the young kangaroo cannot actively suck. The mother therefore places it upon one of her long and slender nipples (the end of which is somewhat swollen), this nipple entering its mouth, and the little creature remaining attached to it. The mother then, by means of the cremaster muscle (before spoken of), squeezes her own milk gland, and so injects milk into the young, which would thus be infallibly choked but for a noticeable peculiarity of its structure, admirably adapted to the circumstances of the case.

In almost all beasts, and in man also, the air-passage or windpipe (which admits air to and from the lungs) opens into the floor of the mouth, behind the tongue and *in front* of the opening of the gullet. Each particle of food, then, as it passes to the gullet, passes over the entrance to the windpipe, but is prevented from falling into it (and so causing death by choking) by the action of a small cartilaginous shield (the *epiglottis*). This shield, which ordinarily stands up in front of the opening into the windpipe, bends back and comes over that opening just when food is passing, and so, at the right moment, almost always prevents food from "going the wrong way." But, in the young kangaroo, the milk being introduced, not by any voluntary act of the young kangaroo itself, but by the injecting action of its mother, it is evident that, did such a state of things obtain in it as has been just described, the result would be speedily fatal. Did no special provision exist, the young one must infallibly be choked by the intrusion of milk into the windpipe. But there is a special provision for the young kangaroo; the upper part of the windpipe (or larynx), instead of lying as in us, and as in most beasts, widely separated from the hinder opening of the nostrils, is much raised (Fig. 3, *a*). It is in fact so elongated in the young kangaroo that it rises right up into the hinder end of the nasal passage, which embraces it. In this way there is free entrance for air from the nostrils into the windpipe by a passage shut off from the cavity of the mouth. All the time the milk can freely pass to the back of the mouth and gullet along each side of this elongated larynx, and thus breathing and milk-injection can go on simultaneously, without risk or inconvenience.

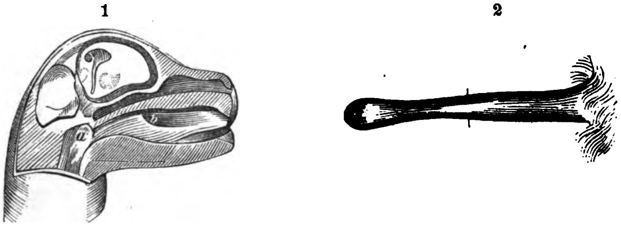

FIG. 3.—1. DISSECTED HEAD OF YOUNG KANGAROO.—*a*, Elongated Larynx; *b*, Cavity of Mouth. 2. Nipple of Mother.

The kangaroo browses on the herbage and bushes of more or less open country, and, when feeding, commonly applies its front-limbs to the ground. It readily, however, raises itself on its hind-limbs and strong tail (as on a tripod) when any sound, sight, or smell, alarms its natural timidity (Fig. 1).

Mr. Gould tells us that the natives (where it is found) sometimes hunt these animals by forming a great circle around them, gradually converging upon them, and so frightening them by yells that they become an easy prey to their clubs.

As to its civilized hunters, the same author tells us that kangaroos are hunted by dogs which run entirely by sight, and partake of the nature of the greyhound and deerhound, and, from their great strength and fleetness, are so well adapted for the duties to which they are trained, that the escape of the kangaroo, when it occurs, is owing to peculiar and favorable circumstances; as, for example, the oppressive heat of the day, or the nature of the ground; the former incapacitating the dogs for a severe chase, and the hard ridges, which the kangaroo invariably endeavors to gain, giving him great advantage over his pursuers. On such ground the females in particular will frequently outstrip the fleetest greyhound; while, on the contrary, heavy old males, on soft ground, are easily taken. Many of these fine kangaroo-dogs are kept at the stock-stations of the interior, for the sole purpose of running the kangaroo and the emu, the latter being killed solely for the supply of oil which it yields, and the former for mere sport or for food for the dogs. Although I have killed the largest males with a single dog, it is not generally advisable to attempt this, as they possess great power, and frequently rip up the dogs, and sometimes even cut them to the heart with a single stroke of the hind-leg. Three or four dogs are more generally laid on; one of superior fleetness to "pull" the kangaroo, while the others rush in upon it and kill it. It sometimes adopts a singular mode of defending itself, by clasping its short, powerful fore-limbs around its antagonist, then hopping away with it to the nearest water-hole, and there keeping it beneath the water until drowned.

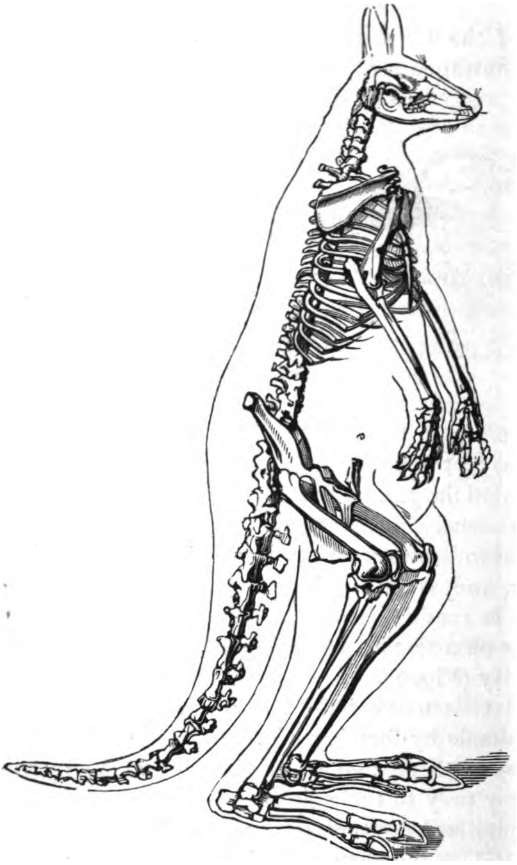

FIG. 4.—SKELETON OF THE KANGAROO.—*a*, Marsupial Bones.

The kangaroo is said to be able to clear even more than fifteen feet at one bound.

Rapidity of locomotion is especially necessary for a large animal inhabiting a country subject to such severe and widely-extending droughts as in Australia. The herbivorous animals which people the plains of Southern Africa—the antelopes—are also capable of very rapid locomotion. In the antelopes, however, as in all hoofed beasts, all the four limbs (front as well as hind) are exclusively used for locomotion. But in kangaroos we have animals requiring to use their front pair of limbs for the purposes of more or less delicate manipulation with respect to the economy of the "pouch." Accordingly, for such creatures to be able to inhabit such a country, the hind pair of limbs must by themselves be fitted alone to answer the purpose of both the front and hind limbs of deer and antelopes. It would seem, then, that the peculiar structure of the kangaroo's limbs is of the greatest utility to it; the front pair serving as prehensile manipulating organs, while the hind pair are, by themselves alone, able to carry the animal great distances with rapidity, and so to traverse wide arid plains in pursuit of rare and distant water. The harmony between structure, habit, and climate, was long ago pointed out by Prof. Owen.

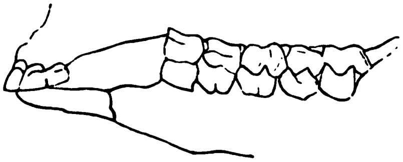

FIG. 5.—TEETH OF KANGAROO.

The kangaroo breeds freely in this country, producing one at a birth. We have young ones every year in our Zoölogical Gardens. A large number of them are reared to maturity, and altogether our kangaroos thrive and do well. One born in our gardens was lately in the habit of still entering the pouch of its mother, although itself bearing a very young one within its own pouch. These animals have been already more or less acclimatized in England. I have myself seen them in grounds at Glastonbury Abbey. Some were so kept in the open by Lord Hill, and some by the Duke of Marlborough. A very fine herd is now at liberty in a park near Tours, in France.

It is a little more than one hundred and five years since the kangaroo was first distinctly seen by English observers. At the recommendation and request of the Royal Society, Captain (then Lieutenant) Cook set sail in May, 1768, in the ship Endeavor, on a voyage of exploration, and for the observation of the transit of Venus of the year 1769, which transit the travelers observed, from the Society Islands, on June 3d of that year. In the spring of the following year the ship started from New Zealand to the eastern coast of New Holland, visiting, among other places, a spot which, on account of the number of plants found there by Mr. (afterward Sir Joseph) Banks, received the name of Botany Bay. Afterward, when detained in Endeavor River (about 15° south latitude) by the need of repairing a hole made in the vessel by a rock (part of which, fortunately, itself stuck in the hole it made), Captain Cook tells us that on Friday, June 22, 1770, "some of the people were sent on the other side of the water, to shoot pigeons for the sick, who at their return reported that they had seen an animal, as large as a greyhound, of a slender make, a mouse-color, and extremely swift." On the next day, he tells us: "This day almost everybody had seen the animal which the pigeon-shooters had brought an account of the day before; and one of the seamen, who had been rambling in the woods, told us on his return that he verily believed he had seen the devil. We naturally inquired in what form he had appeared, and his answer was, says John, 'As large as a one-gallon keg, and very like it; he had horns and wings, yet he crept so slowly through the grass that, if I had not been *afeared*, I might have touched him.' This formidable apparition we afterward, however, discovered to have been a bat (A FLYING FOX). . . . Early the next day," Captain Cook continues, "as I was walking in the morning, at a little distance from the ship, I saw myself one of the animals which had been described; it was of a light mouse-color, and in size and shape very much resembling a greyhound; it had a long tail also, which it carried like a greyhound; and I should have taken it for a wild-dog if, instead of running, it had not leaped like a hare or deer." Mr. Banks also had an imperfect view of this animal, and was of opinion that its species was hitherto unknown. The work exhibits an excellent figure of the animal. Again, on Sunday, July 8th, being still in Endeavor River, Captain Cook tells us that some of the crew "set out, with the first dawn, in search of game, and in a walk of many miles they saw four animals of the same kind, two of which Mr. Banks's greyhound fairly chased; but they threw him out at a great distance, by leaping over the long, thick grass, which prevented his running. This animal was observed not to run upon four legs, but to bound or leap forward upon two, like the jerboa." Finally, on Saturday, July 14th, "Mr. Gore, who went out with his gun, had the good fortune to kill one of these animals which had been so much the subject of our speculation;" adding, "This animal is called by the natives *kanguroo*. The next day (Sunday, July 15th) our kanguroo was dressed for dinner, and proved most excellent meat."

Such is the earliest notice of this creature's observation by Englishmen; but Cornelius de Bruins, a Dutch traveler, saw,[1] as early as 1711, specimens of a species (now named after him, *Macropus Brunii*), which he called *Filander*, and which were kept in captivity in a garden at Batavia. A very fair representation of the animal is given—one showing the aperture of the pouch. This species was, moreover, described both by Pallas[1] and by Schreber.[2]

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[1] *See* Cornelis de Bruins, "Reizen over Moskovie, door Persie en Indie." Amsterdam, 1714, p. 374, Fig. 213.

It is not improbable, however, that kangaroos were seen by the earlier explorers of the western coast of Australia; and it may be that it is one of these animals which was referred to by Dampier, when he tells us that on August 12, 1699, "two or three of my seamen saw creatures not unlike wolves, but so lean that they looked like mere skeletons."

Having now learned something of the structure, habits, and history of the kangaroo, we may proceed to consider its zoölogical, geographical, and geological relations, in order to arrive at the best answer we may to our initial question, "What is a kangaroo?"

First, as to its zoölogical relations: and here it is necessary to recall to mind certain leading facts of zoölogical classification, in order that we may be better able to see with what creatures the kangaroo is, in various degrees, allied.

The whole animal population of the globe is spoken of under the fanciful term, the "animal kingdom," in contrast with the world of plants, or "vegetable kingdom."

The animal kingdom is divided into certain great groups, each of which is called a sub-kingdom; and one, the highest of these sub-kingdoms (that to which we ourselves belong), bears the name *vertebrata*, and it includes all beasts, birds, reptiles, and fishes; and the name refers to the series of bone called *vertebræ*, of which the back-bone or spinal column (and all *vertebrata have* a spinal column) is generally made up.

Each sub-kingdom is made up of subordinate groups, termed classes; and thus the vertebrate sub-kingdom is made up of the *class* of beasts or *Mammalia* (so called because they suckle their young), the class of birds, and other classes.

Each class is made up of subordinate groups, termed *orders;* each order is further subdivided into *families;* each family is made up of *genera;* while every genus comprises one, few, or many species.

In considering the zoölogical relations of the kangaroo, we have then to consider the relations borne by its genera to the other genera of its family, the relations borne by its family to the other families of its order, and finally the relations borne by its order to the other orders of its class (the *Mammalia*)—that class which includes within it all other beasts whatever, and also man.

In the first place, it may be observed, there are many species of kangaroos, arranged in some four genera; but the true kangaroos form a genus, *Macropus*, which is very nearly allied to the three other genera. 2. *Dorcopsis*, with a very large first back tooth. 3. The *tree kangaroos* (*Dendrolagus*), which frequent the more horizontal branches of trees, have the fore-limbs but little shorter than the hind-limbs, and inhabit New Guinea; 4. The *rat-kangaroos* (*Hypsiprymnus*), which have the first upper grinding-tooth large, compressed, and with vertical grooves.

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[1] Pallas, "Act. Acad. Sc. Petrop.," 1777, part ii., p. 299, tab. 4, Figs. 4 and 5.

[2] Schreber, "Sangth.," iii., p. 551, pl. 153, 1778.

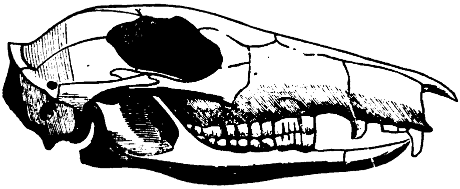

FIG. 6.—SKULL OF A RAT-KANGAROO (*Hypsiprymnus*).

These four genera together constitute the kangaroo's FAMILY, the *Macropodidæ*, the species of which all inhabit Australia and the islands adjacent, but are found nowhere else in the world.

The species agree in having—

1. The second and third toes slender and united in a common fold of skin.
2. The hind-limbs longer than the fore-limbs.
3. No inner *metatarsal* bone.
4. All the toes of each fore-foot provided with claws.
5. Total number of incisors only $\frac{6}{2}$.

These five characters are common to the group, and do not co-exist in any other animals. They form, therefore, the distinguishing CHARACTERS of the kangaroo's family. This family, *Macropodidæ*, is one of the six other families which, together with it, make up that much larger group, the kangaroo's ORDER. As was just said, to understand what a kangaroo is, we must know "what are the relations borne by his *family* to the other families of its order;" and accordingly it is needful for our purpose to take at least a cursory view of those other families.

There is a small animal, called a *bandicoot* (Fig. 7), which, in external appearance, differs very plainly from the kangaroo, but resembles it in having the hind-limbs longer than the fore-limbs, and also in the form of its hind-feet, which present a kangaroo structure, but not carried out to such an extreme degree as in the kangaroo, and therefore approximating more to the normal type of foot, there being a rudimentary inner toe and a less preponderant fourth toe; the second and third toes, however, are still very small, and bound together by skin down to the nails. In the fore-foot, on the contrary, there is a deficiency, the outer toes being nailless or wanting. The cutting-teeth are more numerous, these being I $\frac{10}{8}$.

This little creature is an example of others, forming the family

Peramelidæ—a family made up of creatures none of which much exceed the hare in size, and which, instead of feeding on vegetable substances (as do the kangaroos), eat insects, for which food they are well adapted by the sharp points and ridges which may be seen on their back teeth.

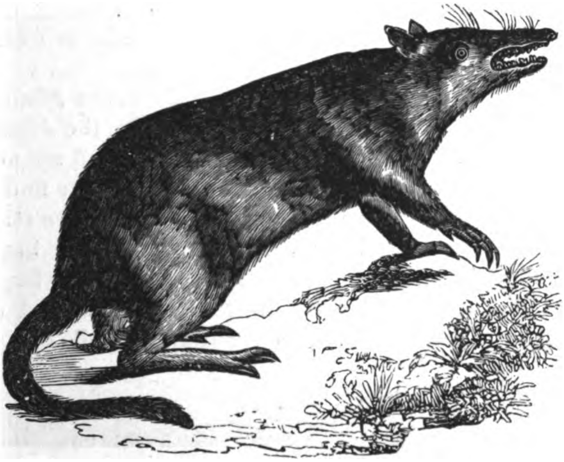

FIG. 7.—LONG-NOSED BANDICOOT (*Perameles*).

One member of this family, *Chœropus* (Fig. 8), is very exceptional in the structure of its hind-feet, which out-kangaroo the kangaroo in the minuteness of all the toes but the fourth, upon which alone the creature walks, while its front-feet are each reduced to two functional digits.

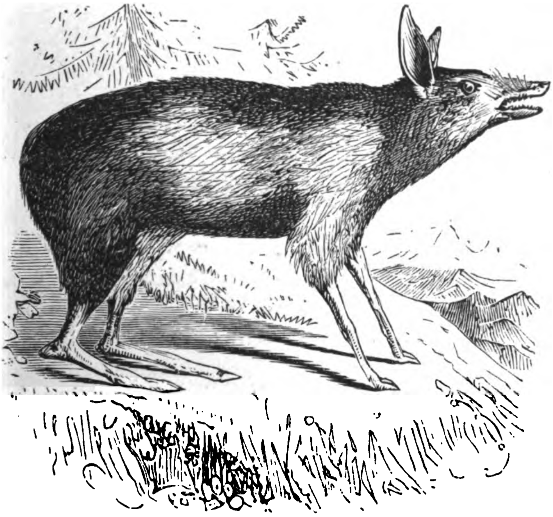

FIG. 8.—CHÆROPUS.

No other known beast besides walks upon a single toe in each hind-foot, save the horse family (horses, asses, and zebras), and they walk upon a different one, namely, that which answers to our middle-toe, while *Chœropus* walks on the next outer one or fourth. No known beast besides *Chœropus* walks upon two toes in each foot, save hoofed creatures, such as the ruminants and their allies; but in them it is the third and fourth toes that are used, while in *Chœropus* it is the second and third toes.

Another animal, called a phalanger (of the genus *Phalangista*), is a type of a third family of the kangaroo's order, the *Phalangistidæ*, a family made up of creatures which live in trees and are nocturnal in their habits, feeding upon fruits and leaves. Here we find the limbs of nearly equal length. Once more we have I $\frac{6}{2}$, and we still have the second and third toes united in a common fold of skin; but the innermost toe (that answering to *our* great-toe) is not only largely developed, but is like that of the apes, directed outward, and capable of being opposed to the other toes, as our thumb can be opposed to our fingers.

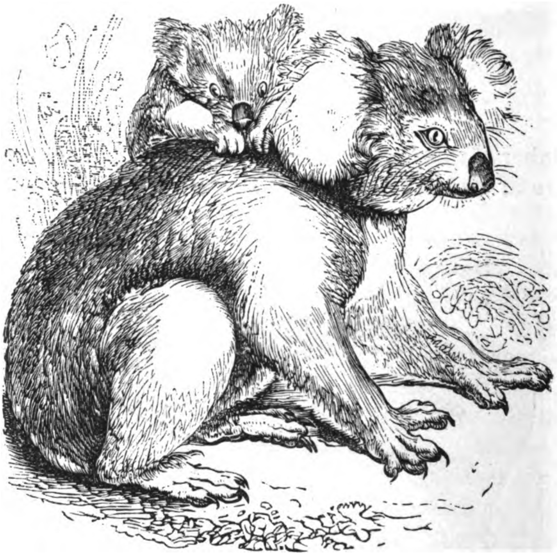

Fig. 9.—The Koala (*Phascolarctus*).

Some of these creatures have prehensile tails. Others have the skin of the flanks enlarged so as to serve them as a parachute in their leaps, whence they are called "flying opossums," just as squirrels, similarly provided, are called "flying" squirrels.

There are two very aberrant members of this family. One, the koala, Fig. 9 (*Phascolarctus*), called the native bear or native sloth, is devoid of any tail.

The other, *Tarsipes*, but little bigger than a mouse, has a long and pointed muzzle, and its teeth are reduced to minute pointed processes, few in number, $\frac{6-6}{5-5}$, situated far apart in each jaw.

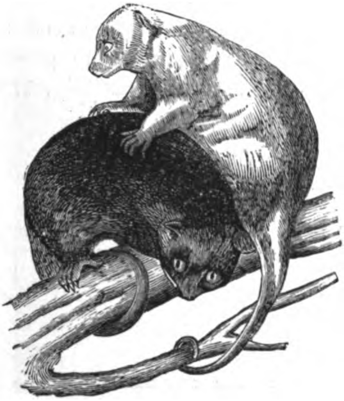

FIG. 10.—CUSCUS ORIENTALIS.

The genus *Cuscus*, closely allied to *Phalangista*, is found in New Guinea and the adjacent islands to Timor (Fig. 10).

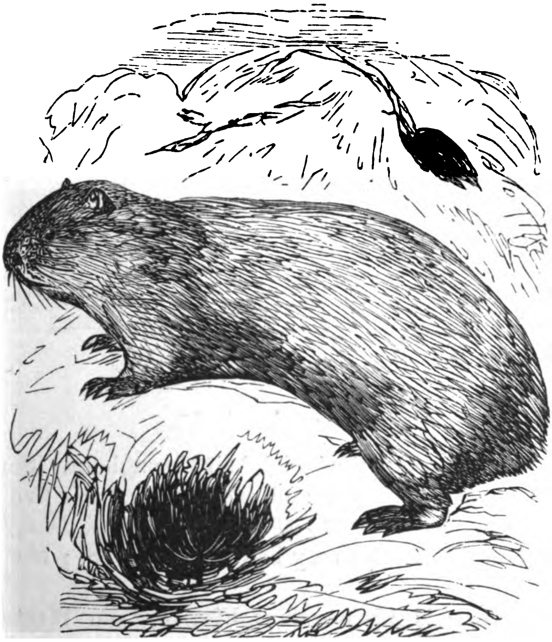

FIG. 11.—THE WOMBAT (*Phascolomys*).

Another animal, the wombat, Fig. 11 (*Phascolomys*), forms by itself a distinct family, *Phascolomyidæ*. It is a burrowing nocturnal animal, about the size of a badger, with rudimentary tail and peculiar feet and teeth.

We still find the second and third toes bound together, limbs of equal length, and all the five toes of the fore-foot with claws (as in the last family), but the great-toe is represented by a small tubercle, while the cutting teeth are $\frac{2}{2}$, growing from persistent pulp through life, as in rats, squirrels, and Guinea-pigs (Fig. 12).

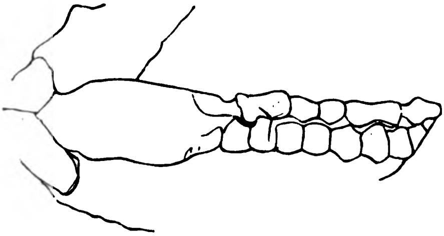

Fig. 12.—Teeth of the Wombat.

We may now pass to a very different family of animals belonging to the kangaroo's order. We pass, namely, to the *Dasyuridæ*, or family of the native cat, wolf, and devil, so named from their predatory or fierce nature. They have well-developed eye-teeth (or canines), and back teeth with sharp cutting blades, or bristling with prickly points. The second and third toes are no longer bound together; and while there are five toes with claws to each fore-foot, the great-toe is either absent altogether or small. The cutting teeth, Fig. 13, are $\frac{8}{6}$, and the tail is long and clothed with hair throughout. Some of these animals are elegantly colored and marked, and all live on animal food. This form (belonging to the typical genus *Dasyurus*, which gives its name to the family) may be taken as a type; but two others merit notice.

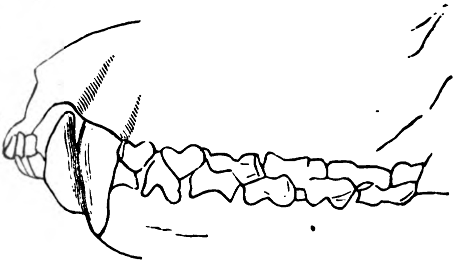

Fig. 13.—Teeth of Dasyurus.

The first of these is *Myrmecobius*, Fig. 14, from Western Australia, remarkable for its number of back teeth, $\frac{8-8}{9-9}$, and for certain geographical and zoölogical relations, to be shortly referred to. With respect to this creature, Mr. Gilbert has told us:

"I have seen a good deal of this beautiful little animal. It appears very much like a squirrel when running on the ground, which it does in successive leaps, with its tail a little elevated, every now and then raising its body, and resting on its hind-feet. When alarmed, it generally takes to a dead tree lying on the ground, and before entering the hollow invariably raises itself on its hind-feet, to ascertain the reality of approaching danger. In this kind of retreat it is easily captured, and when caught is so harmless and tame as scarcely to make any resistance, and never attempts to bite. When it has no chance of escaping from its place of refuge, it utters a sort of half-smothered grunt, apparently produced by a succession of hard breathings."

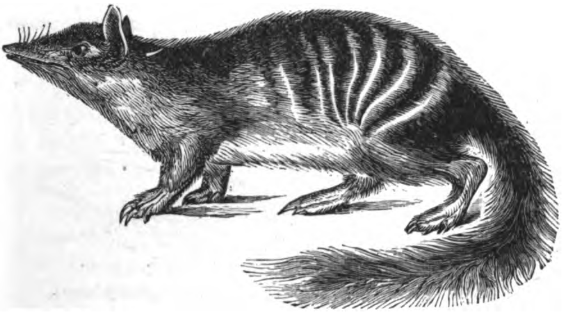

FIG. 14.—MYRMECOBIUS.

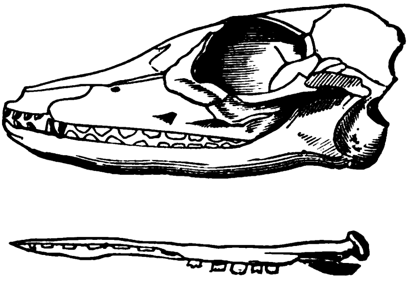

FIG. 15.—SKULL OF MYRMECOBIUS.

The other member of the family *Dasyuridæ*, to which I call the reader's attention, is a very different animal from the *Myrmecobius*. I refer to the largest of the predatory members of the kangaroo's order; namely, to the Tasmanian wolf. It is about the size of the animal after which it is named, and it is marked across the loins with tiger-like, black bands (Fig. 16). It is only found in the island of Tasmania, and will probably very soon become altogether extinct, on account of its destructiveness to the sheep of the colonists. Its teeth have considerable resemblance to those of the dog, and it differs from all other members of the kangaroo's order, in that *mere cartilages* represent those marsupial bones which every other member of the order unquestionably possesses.

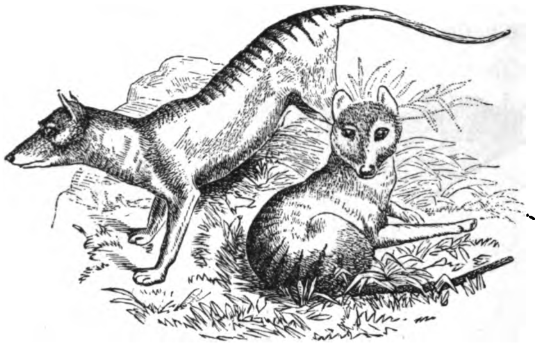

FIG. 16.—TASMANIAN WOLF (*Thalacinus Cynocephalus*).

The last family of the kangaroo's order consists of the true opossum, which (unlike all the animals we have as yet passed in review) inhabits not the Australian region, but America only.

These creatures vary in size from that of the cat to that of the rat.

They are called *Didelphidæ*, and agree with the *Dasyuridæ* in having well-developed canine teeth and cutting back teeth (Fig. 17); in having the second and third toes free, and five toes to the fore-foot. But they differ in that—

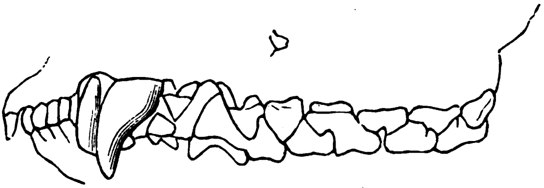

FIG. 17.—TEETH OF OPOSSUM (*Didelphys*).

1. Cutting-teeth $\frac{10}{8}$ (more than in any other animal).
2. A large opposable great-toe.
3. A tail, naked (like that of the rat) and prehensile.

One of them is aquatic in its habits and web-footed. Such are the very varied forms which compose the six families which together make up the kangaroo's order, and such are the relations borne by the kangaroo's family to the other families of the kangaroo's order.

But, to obtain a clear conception of the kangaroo, we must not rest content with a knowledge of its order considered by itself. But we must endeavor to learn the relation of its order to the other orders of that highest class of animals to which the kangaroo and we ourselves both belong, namely, the class *Mammalia*, which class, with the other classes, birds, reptiles, and fishes together, makes up the backboned or *vertebrate* primary division of the whole animal kingdom.

What, then, is the relation of the kangaroo's order—the MARSUPIALIA—to the other orders of the class Mammalia?

Now, these orders are:

1. The order which contains man and apes.
2. That of the bats.
3. That of the mole, shrew, hedgehog, and their allies—all *insectivorous.*
4. That of the dog, cat, weasel, and bear—all *carnivorous.*
5. That of the gnawing animals, such as the rat, squirrel, jerboa, and guinea-pig—all with cutting-teeth $\frac{2}{2}$, with permanent pulps. They are called Rodents.
6. The order containing the sloths.
7. That of the grazing, hoofed quadrupeds—deer, antelopes, and their allies.

Besides three orders of aquatic beasts (seals, whales, and the manatee order), with which we need not be now further concerned.

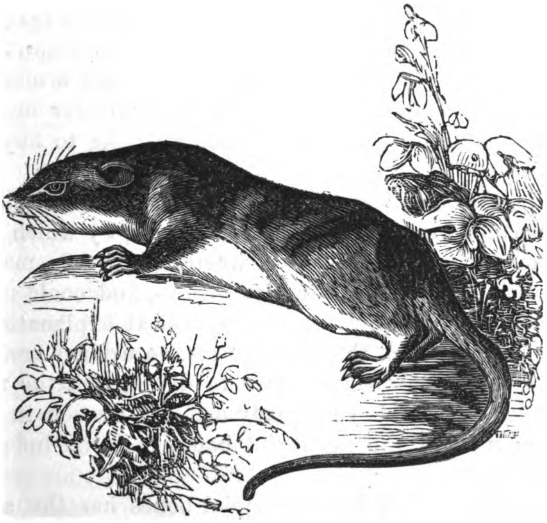

FIG. 18.—THE YAPOCK (*Chironectes*).

Now, in the first place, very noticeable is the much greater diversity of structure found in the kangaroo's order than in any other order of mammals. While each of the *latter* is of one predominate type of structure and habit, we have found in the marsupials the greatest diversity in both.

Some marsupials are, we have seen, arboreal, some are burrowing, some flit through the air, while others range over and graze upon grassy plains. Some feed on vegetable food only, others are as exclusively insectivorous or carnivorous, and their teeth vary much in number and structure. Certain of my readers may wonder that such diverse forms should be thus grouped together, apart from the other mammals. At first sight it might seem more natural to place together *flying opossums* with *flying squirrels;* the *native sloth* with the *true sloth;* the *dog* and *cat-like opossums* with the *true dogs* and *cats;* and, lastly, the *insectivorous marsupials* with the *other insectivora.*

As to the kangaroos themselves, they might be considered as approximating in one respect to the Ruminants, in another to the Rodents.

We have seen that even in Captain Cook's time its resemblance to the jerboa forced itself into notice. And, indeed, in this jerboa (and its first cousin, the *alactaga*) we have the same or even a relatively greater length of hind-limb and tail, and we have the same jumping mode of progression.

Again, in the little jumping insectivorous mammal, the shrew (*Macroscelides*), we meet with excessively long hind-limbs and a jumping habit. More than this: if we examine its teeth, we find both in the upper cutting teeth and in the back teeth great resemblance to those of the kangaroo. And yet there is no real affinity between the kangaroo and such creatures, any more than there is between a non-marsupial truly carnivorous beast and a marsupial carnivore. Indeed, both myself and my readers are far more like the jerboa or weasel than either of the latter is like to any marsupial animal.

The fact is, that all these so varied marsupial forms of life possess in common certain highly-important characters, by which they differ from all other mammals. These characters, however, mainly relate to the structure of their reproductive organs, and could not be here detailed without a long preliminary anatomical explanation; but, as to the great importance of these characters, naturalists are agreed.

Among the characters which serve to distinguish the marsupials, there are two to which I have already called attention in describing the kangaroo; namely, the marsupial bones and the inflected angle of the lower jaw.

Every mammal which has marsupial bones has the angle of its jaw inflected, or else has no angle to its jaw at all; while every animal which has both marsupial bones and an inflected jaw-angle possesses also those special characters of the reproductive system which distinguish the marsupials from all other mammals.

Thus it is clear we have at least two great groups of mammals. One of them—the non-marsupials—contains man; the apes; bats; hedgehog-like beasts (shrews, moles, etc.); cats, dogs, bears, etc.; hoofed beasts; edentates; rodents, and also the aquatic mammals. And this great group, containing so many orders, is named MONODELPHIA.

The other great groups consist of all the marsupials, and no others. It consists, therefore, of the single order, *Marsupialia*, and is called DIDELPHIA.

Another group of mammals is made up of two genera only—the duck-billed platypus, or *Ornithorhynchus*, and the *Echidna*, two most interesting forms, but which cannot be further noticed here. They form, by themselves, a theme amply sufficient for an article, or even half a dozen articles.

As to its zoölogical relations, then, we may say that *the kangaroo is a peculiarly modified form of a most varied order of mammals (the* MARSUPIALS), *which differ from all ordinary beasts* (and at the same time differ from man) *by very important anatomical and physiological characters, the sign of the presence of which is the coexistence of marsupial bones with an inflected angle of the lower jaw.*

We may now proceed to the next subject of inquiry, and consider the space relations (that is, the geographical distribution) of the kangaroo, its family, and order. I have already incidentally mentioned some countries where marsupials are found, but all of those were more or less remote. To find living, in a state of nature, any member of the kangaroo's order, we must at least cross the Atlantic.

When America was discovered by the Spaniards, among the animals found there, and afterward brought over to Europe, were *opossums*, properly so called—marsupials, of the family *Didelphidæ*, which extend over the American Continent, from the United States to the far South. These creatures were the first to make known to Europeans[1] that habit of sheltering the young in a pouch which exists in the kangaroo, and which habit has given the name *Marsupialia* to the whole order. But, though this habit was duly noted, it is not strange that (being the only pouched forms then known) the value of the peculiarity should have been under-estimated. It is not strange that they should have been regarded as merely a new kind of ordinary flesh-eating beasts, since in the more obvious characters of teeth and general form they largely resembled such beasts. Accordingly even the great Cuvier, in the first edition of his "Règne Animal," made them a mere subdivision of his great order of flesh-eating mammals.

But, to find any other member of the kangaroo's order (besides the *Didelphidæ*), in a state of nature, we must go much farther than merely across the Atlantic; namely, to Australia or the islands adjacent to it, including that enormous and unexplored island, New Guinea, which has recently attracted public attention through the published travels of a modern Baron Munchausen.

To return, however, to our subject. To find marsupials at all, we have, as we have seen, to go to the New World. To find nearer allies of the kangaroo, we must go to the *newest* world, Australia; *newest* because, if America merited the title of *new* from its new natural productions as well as its new discovery, Australia may well claim the superlative epithet on both accounts. We have found an indication, in the name Botany Bay, of the interest excited in the mind of Sir Joseph Banks by the new plants as well as by the new animals of Australia. And, indeed, its plants and animals do differ far more from those of the New World (America) than do those of America from those of the Old World.

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[1] The following are some among the earlier notices of these animals: "Histoire d'un Voyage fait en la Terre du Brésil," par Jean de Léry, Paris, 1578, p. 156. Hernande's "Hist. Mex.," p. 330, 1626. "Histoire Naturelle des Antilles," Rotterdam, 1658. "Anatomy of an Opossum," Tyson, Phil. Trans., 1698.

Marsupials, in fact, are separated off from the rest of their class—from the great bulk of mammals—the *Monodelphia*—no less by their geographical limits than by their peculiarities of anatomical structure.

And these geographical limits are at the same time the limits of many groups of animals and plants, so that we have an animal population (or fauna) and a vegetable population (or flora) which are characteristic of what is called the Australian region—the Australian *region*, because the Australian forms of life are spread not only over Australia and Tasmania, but over New Guinea and the Moluccas, extending as far northwest as the island of *Lombok*, while marsupials themselves extend to *Timor*.

In India, the Malay Peninsula, and the great islands of the Indian Archipelago, we have another and a very different fauna and flora—those, namely, of the Indian region, and Indian forms of life extend downward southeast as far as the island of Bali. Now, Bali is separated from Lombok by a strait of but fifteen miles in width. But that little channel is the boundary-line between these two great regions—the Australian and the Indian. The great Indian fauna advances to its western margin, while the Australian fauna stops short at its eastern margin.

The zoölogical line of demarkation which passes through these straits is called "Wallace's line," because its discovery is due to the labors of that illustrious naturalist, that courageous, persevering explorer, and most trustworthy observer, Alfred Wallace, a perusal of whose works I cordially recommend to my readers, since the charm of their style is as remarkable as is the sterling value of their contents. Mr. Wallace pointed out that not only as regards beasts (with which we are concerned to-day), but that also as regards birds, these regions are sharply limited. "Australia has," he says, "no woodpeckers, no pheasants—families which exist in every other part of the world; but instead of them it has the mound-making brush-turkeys, the honey-suckers, the cockatoos, and the brush-tongued lories, which are found nowhere else upon the globe."

All these striking peculiarities are found also in those islands which form the Australian division of the archipelago, while in those islands which belong to its Indian division these Australian birds have no place.

On passing from the island of Bali to that of Lombok, we cross the division between the two. "In Bali," he tells us, "we have barbets, fruit-thrushes, and woodpeckers, while in Lombok these are seen no more; but we have abundance of cockatoos, honeysuckers, and brush-turkeys, which are equally unknown in Bali, or any island farther west."

As to our second point, then—the geographical relations of the kangaroo—we may say that the *kangaroo is one of an order of animals confined to the Australian region and America, the great bulk of which order, including the kangaroo's own family,* MACROPODIDÆ, *is strictly confined to the Australian region.* We may further add that in the Australian region ordinary beasts (*Monodelphia*) are entirely absent, save some bats and a rat or two, and the wild-dog or dingo, which was probably introduced there by man himself.

There only remains, then, for us to inquire, lastly, what relations with past time may be found to exist on the part of the kangaroo's order or of the kangaroo itself. Now, in fact, these relations are of considerable interest. I have spoken of Australia as, what in one sense it certainly is, the *newest world,* and yet *the oldest world* would, in truth, be an apter title for the Australian region.

In these days we hear much of "survivals," as the two buttons behind our frock-coats are "survivals" of the extinct sword-belt they once supported, and the "Oh, yes! oh, yes! oh, yes!" of the town-crier is a "survival" of the former legal and courtly predominance of the French language among us. Well, in Australia we have to-day a magnificent case of zoölogical survival on the largest scale. There, as has already been said, we find living the little *Myrmecobius*, which represents before our eyes a creature living in the flesh to-day, which is like other creatures which once lived here in England, and which have left their relics in the Stonesfield oolite, the deposition of which is separated from our own age by an abyss of past time not to be expressed by thousands of years, but only to be indicated in geological language as the Mesozoic period—the middle of the secondary rocks.

But Australia presents us with a yet more interesting case of "survival." Certain fish-teeth had from time to time been found in deposits of oolitic and triassic date, and the unknown creature to which they once belonged had received the name of *Ceratodus*. Only five years ago this animal, supposed to have been extinct for untold ages, was found still living in Queensland, where it goes by the name of "flat-head." It is a fish of somewhat amphibious habits, as at night it leaves the brackish streams it inhabits, and wanders among the reeds and rushes of the adjacent flats. The anatomy of this animal has been carefully described for us by Dr. Günther.

We have, then, in Australia what may be termed a triassic land, still showing us in life to-day the more or less modified representations of forms which elsewhere have long since passed away from among us, leaving but rare and scattered fragments—relics "sealed within the iron hills."

No member of the Australian families of the kangaroo's order has left its relics in European strata more recent than the secondary rocks. But the American family, *Didelphidæ*, is represented in the earliest Tertiary period by the remains of an American form (a true opossum) having been found by Cuvier in the quarries of Montmartre. He first discovered a lower jaw, and, from its inflected angle, concluded that it belonged to a marsupial animal, and that therefore marsupial bones were hidden in the matrix. Accordingly he predicted that such bones would be found; and, proceeding to remove the enveloping deposit with the greatest care, he laid bare before the admiring eyes of the bystanders the proof of the correctness of his prediction. It is noteworthy, however, that, had this fossil been that of an animal like the Tasmanian wolf, he would have been disappointed, as, though marsupial, it has, as has been already said, not marsupial *bones*, but *cartilages*.

But relics of creatures more closely allied to the kangaroo existed in times ancient historically, though, geologically speaking, very recent. Just as in the recent deposits of South America we find the bones of huge beasts, first cousins to the sloths and armadilloes which live there now, so in Australia there lived beasts having the more essential structural characters of the kangaroo, yet of the bulk of the rhinoceros. Their bones and teeth have been found in the tertiary deposits of Australia. They have been described by Prof. Owen, and are now to be seen preserved in the British Museum and that of the Royal College of Surgeons. It may be that other fossil forms of the middle mesozoic or even of triassic times may, so some believe, have belonged to creatures of the kangaroo's family; but at least there is no doubt that such existed in times of post-tertiary date.

As to our third point—the geological relations of the kangaroo—we may say, then, that "*the kangaroo is one of an order of animals which ranged over the Northern Hemisphere in triassic and oolitic times, one exceptional family lingering in Europe to the Eocene period, and in America to the present day. That the kangaroo itself is a form certainly become fossil in its own region, where, in times geologically recent, creatures allied to it, but of vastly greater bulk, frequented the Australian plains.*"

We may now, then, proceed to answer finally the question, "*What is a kangaroo?*" We may do so because the meaning of the technical terms in which the answer must necessarily be expressed (if not of undue length) has been now explained, as far as space has allowed.

We may say, then, that "*the kangaroo is a didelphous (or marsupial) mammal, of the family* MACROPODIDÆ; *an inhabitant of the*

Australian region, and connected, as respects its order, with triassic times, and possibly even as regards its family also, though certainly (as regards the latter) with the time of the post-tertiary geological deposits."

We have seen what are didelphous and what are monadelphous mammals; what are the respective values of the terms "order," "family," and "genus," and also in what respect the kangaroo differs from the other families of the marsupial order. We have also become acquainted with the distribution of organic life now and with the inter-relations of different geological strata, as far as those phenomena of space and of time concern our immediate subject.

By becoming acquainted with these matters, and by no other way, is it possible to give an intelligent answer to the question, "*What is a kangaroo?*"—*Popular Science Review.*

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LIFE IN GREENLAND.

THE Danish settlements in Greenland date from the year 1721, when a colony was established at Godthaab, in latitude 64° north. The country had been visited and colonies settled there as early as the tenth century by Icelanders; but these Icelandic colonies were utterly destroyed, probably by the pestilence known as the "black-death" in the fourteenth century, or early in the fifteenth. The present Danish settlements are all situated on the west coast, and contain about 10,000 inhabitants, all Esquimaux with the exception of a few hundred, who are Danes. The region of Disco Bay may be regarded as the type of the entire western coast of Greenland. The aspects of Nature and the conditions of human life, as presented in this region, are graphically portrayed by Dr. Robert Brown, F. R. G. S., in the *Geographical Magazine*, and in the following pages we purpose to epitomize, for the benefit of our readers, the account given by this very competent observer. Dr. Brown, we would add, is probably the highest living authority on all scientific questions connected with Greenland; he has written a number of memoirs upon the geology, meteorology, etc., of the country, which are held in the very highest esteem by men of science.

Disco Bay is situated between the parallels of about 68° and 70° north latitude. On the west lies Disco Island, and on the east Greenland. Nowhere are the cliffs high, and the southern shore is in general flat and uninteresting. About Christianshaab (latitude 69°), and farther to the north, the shores are backed by bare rocky hills of about 1,000 or 1,200 feet—rounded knolls of gneiss, ice-shaven and worn. Between these higher grounds run birch and willow-covered mossy valleys, bright with running streams and waterfalls during the brief arctic summer. Everywhere are indubitable signs that the extensive *mer de glace*, which is believed to cover the whole interior of Greenland, once covered at least the greater part of what is now the uncovered or "fast-land" of the Danes. The ice is again beginning to encroach on the land, and everywhere in this vicinity there are proofs of a gradual subsidence of the ground.

From the fossil remains of numerous land-plants and a few insects found in the Miocene beds of Disco Island, it appears that in comparatively recent times a luxuriant vegetation, somewhat similar in character to that of California or the Southern United States, flourished in these arctic wastes. Luxuriant evergreen-oaks, magnolias, and sequoias, grew where now is found only the dwarf-willow, creeping along the ground with a stem not over half an inch in diameter. Among the fossil trees of Greenland, Prof. Heer has discovered three distinct species of sequoia, nine of oak, four of which were evergreen, like the Italian oak, two beeches, a chestnut, two planes, and a walnut. "Besides these," writes Prof. Heer, "American species, such as the magnolias, sassafrasses, and liquidambars, were represented there; and the characters of the ebony-tree are to be distinguished in two of the species. The hazel, the sumach, the buckthorn, and the holly, the guelder-rose, and the white, probably formed the thickets at the borders of the woods; while the vine, the ivy, and the sarsaparilla, climbed over the trees of the virgin forest, and adorned them with garlands. In the shadow of the wood grew a profusion of ferns, which covered the soil with their elegant fronds. The insects which gave animation to these solitudes are not all lost. The impressions of these which have reached us show that *Chrysomelas* and *Castilidæ* enjoyed themselves in the sun, and large *Trogsitæ* pierced the bark of the trees, while charming *Cicadellæ* leaped about among the herbage." In all, about 167 species of Miocene plants have been discovered in Greenland.

The coal found on Disco Island is, like all tertiary lignites, of poor quality, but yet, when mixed with English coal, it forms a good fuel for household and even for steaming purposes. It is mined to a small extent for the use of the settlements around the bay. Soapstone is found in some places in the primitive rocks, on the southern shores of Disco Bay; it was at one time extensively employed by the Esquimaux for making various domestic utensils, but is now much less used, owing to the introduction of vessels of iron, copper, and tin. There is no other economic mineral, cryolite being only found in one locality, Arsut Fiord, in South Greenland.

In the winter the cold is extreme in the region of Disco Bay, and the ground is generally thickly covered with snow from September till May or early June. During this period the whole sea is covered with ice, and the Danes and Esquimaux visit from settlement to settlement in sledges drawn by dogs. During the summer, under the four months of continual daylight, the snow soon melts over the lower lands, and the heat is often extreme. Mosquitoes are troublesome, and, there being no shelter from the rays of the sun reflected from the snow, ice, and bare rocks, traveling is frequently attended with great discomfort. The day may be bright and sunny in the morning, and in the evening snow, sleet, and all the concomitants of spring or winter. During the short summer season vegetation springs up apace and soon comes to maturity. In September the weather is uncertain and the nights are very dark and cold.

The trade of Danish Greenland is a strict crown monopoly, and is administered by government officials solely for the benefit of the natives. The principle adopted is to buy the natives' blubber, skins, ivory, etc., at a low price and to sell to them articles of European manufacture which are necessary to their comfort at an equally low figure; coffee and other luxuries are sold at a good profit. The surplus is credited to each district, and expended for the public good, by the little local parliaments (Partisoks) of the districts, the members of which (partisæts) are elected by universal suffrage. The settlements are known as colonies, and each is presided over by a "colonibestyrer" (*best man in the colony*). The other notables of the colony are the colonibestyrer's assistant, the cooper, the carpenter, and, if the settlement is large, the Lutheran parson, and the schoolmaster—the latter generally an educated native. The most exciting event in the settlements is the arrival of the annual ship from Copenhagen. Pianos are not unknown in the houses of the Danish officials, and the Tauchnitz edition of the best English authors is to be found in the "governor's" house.

The Danish Government treat the natives with the most paternal care. No spirits are allowed to be sold to them, schools are provided, and altogether the rule of the little northern kingdom is productive of very good results. Theft is practically unknown in Danish Greenland.

The vegetation around Disco Bay is, during the brief summer, rather luxuriant; the rocks are bright with mosses, and gayly-colored flowers peep out from the crannies. In the Upernivik district the birch is said to grow high enough in localities to cover the reindeer. Such giant shrubs are looked upon with pride by the natives. They take visitors to see them, and point to these extraordinary specimens of vegetation with an air as of "See this and die!"

Hunting and fishing form the sole occupation of those natives who are not in the government service. The white bear is almost extinct in this region; farther north they are more numerous. The arctic fox is common. The native dog is threatened with extermination by a peculiar disease which first appeared in Greenland a few years ago. The cat has become domesticated. The mouse and rat are regularly introduced every summer with the European ships, but rarely survive the winter. The arctic hare is common. The reindeer is now so rare in the vicinity of Disco Bay that few natives care to go hunting it. The seals are the main staple of the Esquimaux hunt. Large numbers are killed, both in summer and winter, but chiefly on the ice-fields during the latter season. The right-whale is now only a rare visitor. The white whale and the narwhal are often killed.

All the more common arctic birds visit Disco Bay in the summer, but, with the exception of the ptarmigan and some of the raptorial birds, they migrate during the winter. There are no reptiles in Greenland, but the salt-water fishes are numerous. Shark-fishing forms a considerable branch of industry. The kalleraglek, or small halibut, is caught in Disco Bay; among the Danes it forms a favorite dish, when sliced and dried. About six species of *Salmo* are found in Greenland. Both the trout and the salmon are excellent, though they have a thick layer of fat beneath the skin. The marine invertebrata are numerous. Insect-life is poor; a few butterflies are seen during the summer months; some *Coleoptera*, a few *Diptera*, *Hymenoptera*, etc., go to make up the limited insect fauna of the region of Disco Bay.

SCIENCE AND RELIGION.[1]

BY REV. CHARLES F. DEEMS, D. D.

THIS recent cry of the "Conflict of Religion and Science" is fallacious, and mischievous to the interests of both science and religion; and would be most mournful if we did not believe that, in the very nature of things, it must be ephemeral. Its genesis is to be traced to the weak foolishness of some professors of religion, and to the weak wickedness of some professors of science. No man of powerful and healthy mind, who is devout, ever has the slightest apprehension that any advancement of science can shake the foundations of that faith which is necessary to salvation. No man of powerful and healthy mind, engaged in observing, recording, and classifying facts, and in searching among them for those identities and differences which point to principles and indicate laws, ever feels that he suffers any embarrassment or limitations in his studies by the most reverent love he can have for God as his Father, or the most tender sympathy he can have for man as his brother, or that hatred for sin which produces penitence, or that constant leaning of his heart on God which produces spiritual-mindedness, or that hope of a state of immortal holiness which has been the ideal of humanity in all ages.

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[1] **Extract from the opening address at the inauguration of Vanderbilt University, by Charles F. Deems, D. D., pastor of the Church of the Strangers, New York, October 4, 1875.**

All this dust about "the conflict" has been flung up by men of insufficient faith, who doubted the basis of their faith; or by men of insufficient science, who have mistaken theology or the Church for religion; or by unreasonable and wicked men, who have sought to pervert the teachings of science so as to silence the voice of conscience in themselves, or put God out of their thoughts, so that a sense of his eternal recognition of the eternal difference between right and wrong might not overawe their spirits in the indulgence of the lust of the flesh, the lust of the eye, and the pride of life. It may be profitable to discriminate these; and, if badges and flags have become mixed in this fray, it may be well to readjust our ensigns, so that foes shall strike at only foes.

It is, first of all, necessary to settle distinctly what science is, as well as what it is not; and also, what religion is, as well as what it is not.

We can all afford to agree upon the definition rendered by the only man who has been found in twenty-two centuries to add anything important to the imperial science of logic. Sir William Hamilton defines science as "a complement of cognitions, having in point of form the character of logical perfection, and in point of matter the character of real truth." Under the focal heat of a definition like this, much that claims to be science will be consumed. It is the fashion to intimate, if not to assert, that it is much more easy to become scientific than to become religious; that in one case a man is dealing with the real, in the other with the ideal; in the one case with the comprehensible, in the other with the incomprehensible; in the one case with that which is certain and exact, and in the other case with that which at best is only probable and indefinite.

There can be no doubt, among thoughtful men, of the great value of both science and religion. A thinker who is worth listening to is always misunderstood if it be supposed that he means to disparage either. An attempt to determine the limits of religion is no disparagement thereof, because all the most religious men who are accustomed to think are engaged in striving to settle those limits, in order that they may have advantage of the whole territory of religion on the one hand, and on the other may not take that as belonging to religion which belongs to something else.

Now, if Sir William Hamilton's definition is to be taken, we shall perceive that he represents science in its quality, in its quantity, and in its form. Cognition of something is necessary for science. Then, (1) the knowledge of things known must be true; (2) that knowledge must be full, and (3) it must be accurate; it must be in such form as to be most readily and successfully used by the logical understanding for purposes of thought.

This sets aside very much that has been called science, and, as it seems, perhaps nearly all that which has been the material used by those who have raised the most smoke over this "conflict" question.

"Guesses at truth" are valuable only as the pecking at a plastered wall, to find where a wooden beam runs, is useful; but a guess is not knowledge. A working hypothesis were not to be despised, although the student of science might feel quite sure in advance that when he had learned the truth in this department he would throw the hypothesis away. A working hypothesis, like a scaffold, is useful; but a scaffold is not a wall. Art is not science. Art deals with the appearances, science with the realities, of things. Art deals with the external, science with the internal, of a thing; art with the phenomenon, science with the *noumenon*. It must be the "*real* truth" which we know, and know truly.

Weak men on both sides have done much harm—the weak religionists by assuming, and the weak scientists by claiming, for guesses and hypotheses, the high character and full value of real truth. The guesses of both have collided in the air, and a real battle seemed impending; but it was only "guesses" which exploded—bubbles, not bombs; and it is never to be forgotten that a professor of religion has just as much right to guess as a professor of science, and the latter no more right than the former, although he may have more skill.

No man can abandon a real truth without degradation to his intellectual and moral nature; but Galileo, Kepler, and Newton, in their studies from time to time, employed and discarded theory after theory, until they reached that which was capable of demonstration. It was only that which took its place as science. In the case of Kepler, it is known what great labor he spent in attempting to represent the orbit of Mars by combinations of uniform circular motion. His working hypothesis was the old doctrine of epicyclic curves. But his great labor was not fruitless, as has been carelessly asserted. The theory was false, and therefore not a part of real science; but, working on it, he discovered that the orbit of Mars is an ellipse, and this led him to the first of his three great laws of planetary motion, and enabled him almost immediately to discover the second. Here was a great intellect employing as a working hypothesis a theory which has always been false, and now is demonstrably false. It was not science.

Now if, while scientific men are employing working hypotheses merely as such, men representing religion fly at them as if they were holding those hypotheses as science, or if men representing science do set forth these hypotheses as if they were real knowledge of truth, and proceed to defend them as such, then much harm is done in all directions.

In the first instance, the religious man shows an impatience which is irreligious. "He that believeth doth not make haste." It is unfair to criticise any man while he is doing. Let him do what he will do; then criticise *the deed.* The artist has laid one pigment on his palette, and he is criticised before it is known what others he intends to mix with it, to procure what shade, to produce what effect. Wait until all the paint is on the canvas, and the artist has washed his brushes and drawn the curtain from his picture; then criticise *the picture.*

This impatient and weak criticism on the part of religious men is injurious to scientific progress, as well as to the progress of religion. For the latter, it makes the reputation of unfairness; for the former, it does one of two bad things: it obstructs free discussion among students of science, or pushes them into a foolish defiance of religion. Men must co-work with those of their own sphere of intellectual labors. They must publish guesses, conjectures, hypotheses, theories. Whatever comes into any mind must be examined by many minds. It may be true, it may be false; there must be no prejudgment. Now if, because our scientific men are discussing a new view, our religious men fly among them and disturb them by crying "Heresy!" "Infidelity!" "Atheism!" those students must take time to repel the charges, and thus their work be hurt. If let alone, they may soon abandon their false theory. Certainly, if a proposition in science be false, the students of science are the men likeliest to detect the falsehood, however unlikely they may be to discover the truth that is in religion. Nothing more quickly destroys an error than to attempt to establish it scientifically.

The premature cries of the religious against the scientific have also the effect of keeping a scientific error longer alive. Through sheer obstinacy the assailed will often hold a bad position, which, if not attacked, had been long ago abandoned. And we must have noticed that Nature seems quite as able to make scientific men obstinate as grace to do this same work for the saints.

No man should be charged with being an atheist who does not, in distinct terms, announce himself to be such; and in that case the world will believe him to be too pitiful a person to be worth assailing with hard words. But as you may drive a man away from you by representing him as your enemy, so a scientific man may be driven from the Christian faith, if convinced that the Christian faith stands in the way of free investigation and free discussion; or, he may hold on to the faith because he has brains enough to see that one may be most highly scientific and most humbly devout at the same time; but by persecution he may be compelled to withdraw from open communion with "those who profess and call themselves Christians." Then both parties lose—what neither can well afford to lose—the respect and help which each could give the other. When the son of a religious teacher turns to the works of a man whom he has heard that father denounce, and finds in any one page of those books more high religious thought than in a hundred of his father's commonplace discourses, a sad state of feeling is produced, and many mistakes are likely to follow.

Sir William Hamilton's definition of science has for *genus* "a complement of cognitions," and for *differentia* "logical perfection of form," and "real truth of matter." The definition is a demand for a certain fullness. We can only conjecture, in the case of any particular science, how much knowledge such a man as Sir William Hamilton would regard as a "complement." But students of science do well to remind themselves that it is impossible to exceed, and very difficult to succeed, and the easiest thing imaginable to fall short. In other words, we have never been able to collect more material of knowledge than the plan of any temple of science could *work in*, and really did not demand for the completion of the structure, and that very few temples of science have been finished, even in the outline, while all the plain of thought is covered by ruins of buildings begun by thinkers, but unfinished for want of more knowledge. Even where there has been gathered a sufficient amount of knowledge to be wrought by the logical understanding into the form of a science, so that such a mind as Hamilton's would admit it as a science—i. e., a sufficient complement of cognitions of truths put in logical form—another age of labor, in other departments, would so shrink this science that, in order to hold its rank, it would have to *work in* the matter of more knowledge, and, to preserve its symmetry, be compelled to readjust its architectural outlines. In other words, what is science to one age may not be science to its successor, because that successor may perceive that, although its matter had the character of real truth, and its form the character of logical perfection, *as far as it went*, nevertheless, there were not enough cognitions; not enough, just because in the later age it was possible to obtain additional cognitions, which could not have been obtained earlier.

And, in point of fact, has not this been the history of each of the acknowledged sciences? And can any significance be assigned to Sir William Hamilton's definition without taking the word "complement" to mean *all the cognitions possible at the time?* Now, unless at one time men have more cognitions of any subject than at another time, one of two things must be true: either (1) no new phenomena will appear in that department, or (2) no abler observer will arise. But the history of the human mind in the past renders both suppositions highly improbable. If no new phenomena appear, we shall have observers abler than have existed, because, although it were granted that no fresh accessions of intellectual power came to the race, each new generation of observers would have increased ability, because each would have the aid of the instruments and methods of all predecessors. When we go back to consider the immense labor performed by Kepler in his investigations which led to his brilliant discoveries, we feel that if his nerves had given way under his labors, and domestic troubles, and financial cares, or his industry had been just a little less tenacious, he would have failed in the prodigious calculations which led him to his brilliant discoveries, and gave science such a great propulsion. Just five years after the publication of Kepler's "New Astronomy" the Laird of Merchison published, in Scotland, his "*Mirifici Logarithmorum Canonis Descriptio.*" If Kepler had only had Napier's logarithms! But succeeding students have enjoyed this wonderful instrumental aid, and done great mental work with less draught on their vital energies.

The very facts, then, which make us proud of modern science should make scientific men very humble. It will be noticed that the most arrogant cultivators of science are those who are most ready to assail such religious men as are rigid, and hold that nothing can be added to or taken away from theology; and such scientific men make this assault on the assumption that physical sciences are fixed, certain, and exact. How ridiculous they make themselves, a review of the history of any science for the last fifty years would show. Is there any department of physical science in which a text-book used a quarter of a century ago would now be put into the hands of any student? The fact is that any man, who is careful of his reputation, has some trepidation in issuing a volume on science, lest the day his publishers announce his book the morning papers announce, also, a discovery which knocks the bottom out of all his arguments. This shows the great intellectual activity of the age—a matter to rejoice in, but it should also promote humility, and repress egotism in all well-ordered minds. There is, probably, no one thing known in its properties and accidents, in its relations to all abstract truths and concrete existence. No one thing is exactly and thoroughly known by any man, or by all men. Mr. Herbert Spencer well says: "Much of what we call science is not exact, and some of it, as physiology, can never become exact" ("Recent Discussions," p. 158). He might have made the remark with greater width, and no less truth, since every day accumulates proof that that department of our knowledge which we call the exact sciences holds an increasingly small proportion to the whole domain of science.

There is one important truth which seems often ignored, and which should frequently be brought to our attention, viz., that the propositions which embody our science are statements not of absolute truths, but of probabilities. Probabilities differ. There is that which is merely probable, and that which is more probable, and that which is still much more probable, and that which is so probable that our faculties cannot distinguish between this probability and absolute certainty; and so we act on it as if it were certain. But it is still only a "probability," and not a "certainty." It seems as though it would forever be impossible for us to determine how near a probability can approach a certainty without becoming identical with that certainty.

Is not all life a discipline of determining probabilities? It would seem that God intends that generally the certainties shall be known only to himself. He has probably shown us a very few certainties, more for the purpose of furnishing the idea than for any practical purpose, as absolute certainty is necessary for him, while probabilities are sufficient for us. All science is purely a classification of probabilities.

We do not *know* that the same result will follow the same act in its several repetitions, but *believe* that it will; and we believe it so firmly that if a professor had performed a successful experiment before a class in chemistry, he would not hesitate to repeat the experiment after a lapse of a quarter of a century. Scientific men are not infidels. Of no men may it be more truly said that they "walk by faith." They do not creep, they march. Their tread is on made ground, on probabilities; but they believe they shall be supported, and according to their faith so is it done unto them.

And no men better know than truly scientific men that this probability can never become certainty. In the wildest dreams of fanaticism—and there are fanatics in the laboratory, as there are in the sanctuary of God and in the temple of Mammon—it has never been believed that there shall come a man who shall know all things that are, all things that have been, all things that shall be, and all things that can be, in their properties, their attributes, and their relations. Until such a man shall arise, science must always be concerned with the cognition of that which is the real truth as to probabilities, or with probable cognitions of that which is not only real truth, but absolute truth. A scientific writer, then, when he states that any proposition has been "proved," or anything "shown," means that it has been proved probable to some minds, or shown to some—perhaps to all—intelligent persons as probable. If he have sense and modesty, he can mean no more, although he does not cumber his pages or his speech with the constant repetition of that which is to be presumed, even as a Christian in making his appointments does not always say *Deo volente*, because it is understood that a Christian is a man always seeking to do what he thinks to be the will of God, in submission to the providence of God.

A scientific man ridicules the idea of any religious man claiming to be "orthodox." It must be admitted to be ridiculous, just as ridiculous as would be the claim of a scientific man to absolute certainty and unchangeableness for science. The more truly religious a man is, the more humble he is; the more he sees the deep things of God, the more he sees the shallow things of himself. He claims nothing positively. He certainly does not make that most arrogant of all claims, the claim to the prerogative of infinite intelligence. There can exist only one Being in the universe who is positively and absolutely orthodox, and that is God. In religion, as in science, we walk by faith; that is, we believe in the probabilities sufficiently to act upon them.

So far from any conflict being between science and religion, their bases are the same, their modes are similar, and their ends are identical, viz., what all life seems to be, that is, a discipline of faith.

It is not proper to despise knowledge, however gained: whether from the exercise of the logical understanding, or from consciousness, or from faith; and these are the three sources of knowledge. That which has been most undervalued is the chief of the three; that is, faith.

We *believe* before we acquire the habit of studying and analyzing our consciousness. We *believe* before we learn how to conduct the processes of our logical understanding.

We can have much knowledge by our faith without notice of our consciousness, and without exertion of our reasoning faculties; but we can have no knowledge without faith. We can learn nothing from our examination of any consciousness without faith in some principle of observation, comparison, and memory. We can acquire no knowledge by our logical understanding without faith in the laws of mental operations.

This last statement, if true, places all science on the same basis with religion. Although so familiar to many minds, we may take time to show that it is true.

For proof let us go to a science which is supposed to demonstrate all its propositions, and examine a student in geometry. We will not call him out on the immortal 47 : I of Euclid. We can learn all we need from a bright boy who has been studying Euclid a week. The following may represent our colloquy:

Q. Do you know how many right angles may be made by one straight line upon one side of another straight line?

A. Yes; two, and only two. Innumerable angles may be made by two straight lines so meeting, but the sum of all the possible angles will be two right angles.

Q. You say you know that. How do you know that you know it?

A. Because I can prove it. A man knows every proposition which he can demonstrate.

Q. Please prove it to me.

The student draws the well-known diagrams. If he follows Euclid, he begins with an argument like this:

A. There are obviously two angles made when a straight line stands on another straight line.

Q. My eyes show me that.

In answer he gives us the well-known demonstration of Euclid, to show that the sum of the two angles is equal to two right angles; and, when he has finished and reached the Q. E. D., he and his examiners *know* that this proposition is true, because he has proved it.

But when we examine his argument we find that he has made three unproved assumptions—namely: 1. That a thing cannot at the same time, *be* and *not be;* 2. That if equals be added to equals, the wholes are equal; 3. That things which are equal to the same are equal to one another. It so happens that each of these propositions which he has assumed to be true is, if true, much more important than the proposition which he has proved. Let us point out these three assumptions to our bright student, and then resume our catechism.

Q. Could you possibly prove this proposition in geometry if any one of those three assumed propositions were not granted?

A. No.

Q. Then, if we deny these assumptions, can you prove them?

A. No; but can you deny them?

No, we cannot deny them, and cannot prove them; but we believe them, and therefore have granted them to you for argument, and know your proposition of the two right angles to be true, because you have proved it.

Now, here is the proposition which Euclid selected as the simplest of all demonstrable theorems of geometry, in the demonstration of which the logical understanding of a student cannot take the first step without the aid of faith.

From the student let us go to the master. We go to such a teacher as Euclid, and in the beginning he requires us to believe three propositions, without which there can be no geometry, but which have never been proved, and, in the nature of things, it would seem never could be proved—namely, that space is infinite in extent, that space is infinitely divisible, and that space is infinitely continuous. And we believe them, and use that faith as knowledge, and no more distrust it than we do the results of our logical understandings, and are obliged to admit that geometry lays its broad foundations on our faith.

Now, geometry is the science which treats of forms in their relations in space. The value of such a science for intellectual culture and practical life must be indescribably important, as might be shown in a million of instances. No form can exist without boundaries, no boundaries without lines, no line without points. The beginning of geometric knowledge, then, lies in knowing what a "point" is, the existence of forms depending, it is said, upon the motion of points. The first utterance of geometry, therefore, must be a definition of a point. And here it is: "A point is that which has no parts, or which has no magnitude." At the threshold of this science we meet with a mystery. "A point is"—then, it has existence—"is" what? In fact, in form, in substance, it is nothing. A logical definition requires that the *genus* and *differentia* shall be given. What is the *genus* of a "point?" Position, of course. Its *differentia* is plainly seen. It is distinguished from every thing else in this, that every thing else is *something somewhere*, and a point is *nothing somewhere ;* every thing HAS *some* characteristic, a point has *none*. A point is visible or invisible. Is it visible? Then we can see that which is without parts or magnitude. What is it we see when we do not see any part, do not see any magnitude? Is it substantial or ideal? If substantial, how do we detect its substantial existence? If ideal, how can an idea have motion, and by simple motion become a substantial existence? Are we not reduced to this? Ideals produce substantials, or invisible substantials, upon motion, produce visible substantials; or that which is necessary to matter—namely, form—owes its existence to that which is neither substantial nor ideal—to nothing, in fact. The entire and sublime science of geometry, at one time the only instrument of culture among the Greeks, and so esteemed by Plato that he is said to have written over his door, "Let no one enter here who does not know geometry," in all its conceptions, propositions, and demonstrations, rests upon the conception of that which has no parts, no magnitude. The old saw of the school-men was, "*Ex nihilo nihil fit.*" If each visible solid owes its form to superficies, and each superficies its form to lines, and each line its form to a point—and a point has no form, because it has no parts—then, who shall stone the man that cries out, "*Ex nihilo geometria fit?*"

But lay the first three definitions of geometry side by side: 1. "A point is that which has no parts, or which has no magnitude." 2. "A line is length without breadth." 3. "The extremities of a line are points." Study these, and you will probably get the following results: That which has no parts produces all the parts of that which occupies space without occupying space, and which, although it occupies no space, has extremities, to the existence of which it owes its own existence; and those extremities determine the existence of that which has parts made up of multiplications of its extremities which have no parts. Now, you must know at least that much, or else stay out of Plato's house.

This useful science, without which men could not measure their little plantations, or construct their little roads on earth, much less traverse and triangulate the ample fields of the skies, lays for its necessary foundation thirty-five definitions, three postulates, and twelve axioms, the last being propositions which no man has ever proved; and these fifty sentences contain as much that is incomprehensible, as much that must be granted without being proved, as much that must be believed, although it cannot be proved, as can be found in all the theological and religious writings from those of John Scotus Erigina down to those of Richard Watson, of England, or Charles Hodge, of Princeton.

Does any man charge that this is a mere logical juggle? Then he shall be called upon to point out wherein it differs from the methods of those who strive to show that there is a real conflict between real science and real religion. If any man shall charge me with being an infidel as touching geometry, and try to turn me out of the church of science, I shall become hotly indignant, because I know that Euclid did not believe more in geometry than I do, and I believe as much in the teachings of geometry as I do in the teachings of theology, regarding them both, as Aristotle did, as mere human sciences, ranking theology with psychology, geology, and botany. And, being by profession a theologian, I certainly believe in theology.

And this brings us back to what was stated in the beginning, as one of the causes of this cry of "conflict." It is the confounding of theology with religion. Theology is not religion any more than psychology is human life, or zoölogy is animal life, or botany is vegetable life. Theology is objective; religion is subjective. Theology is the scientific classification of what is known of God; religion is a loving obedience to God's commandments. Every religious man must have some theology, but it does not follow that every theologian must have some religion. We never knew a religious man without some kind of a theology, nor can we conceive such a case. But we do know some theologians who have little religion, and some that seem to have none. There may be a conflict between theology and some other sciences, and religious men may deplore *that* conflict, or may not, according to their measure of faith. There are those whose faith is so large and strong that they do not deplore such a conflict, because they know that if, for instance, a conflict should come between geology and theology, and geology should be beaten, it will be so much the better for religion; and if geology should beat theology, still so much the better for religion: according to the spirit of the old Arabic adage, *If the pitcher fall on the stone, so much the worse for the pitcher; and if the stone fall on the pitcher so much the worse for the pitcher.* Geologists, psychologists, and theologists, must all ultimately promote the cause of religion, because they must confirm one another's truths, and explode one another's errors; and a religious man is a man whose soul longs for the truth, who loves truth because he loves God, who knows if the soul be sanctified it must be sanctified by the truth, even as the mind must be enlarged and strengthened by the truth. He knows and feels that it would be as irreligious in him to reject any truth found in Nature, as it would be for another to reject any truth found in the Bible.

But there is no necessary conflict between even theology and any other science. Theology has to deal with problems into which the element of the infinite enters. It will therefore have concepts some two of which will be irreconcilable, but not therefore contradictory. For instance, to say that God is "an infinite person" is to state the agreement of two concepts which the human mind is supposed never to have reconciled, and never to be able to reconcile. But they are not contradictory. If one should say that there is in the universe a circular triangle, we should deny it, not because the concept of a triangle is *irreconcilable* with the concept of a circle, as consistent in the same figure, which is quite true, but because they are *contradictory*. What is irreconcilable to you may be reconcilable to another mind, because "irreconcilable" indicates the relation of the concept to the individual intellect; but what is contradictory to the feeblest is contradictory to the mightiest mind, because "contradictory" represents the relation of the concepts to one another.

In the definition of a *person* there is nothing to exclude infinity, and in the definition of *infinite* there is nothing to exclude personality. There is no more exclusion between "person" and "infinite" than between "line" and "infinite;" and yet we talk of infinite lines, knowing the irreconcilability of the ideas, but never regarding them as contradictory.

Writers of great ability sometimes fall into this indiscrimination. For instance, a writer whom I greatly admire, Dr. Hill, former President of Harvard College, in one paragraph (on "The Uses of Mathesis," in *Bibliotheca Sacra*), seems twice to employ "contradictory" in an illogical sense, even when he is presenting an illustration which goes to show most clearly that in other sciences, as well as in theology, there are propositions which we cannot refuse to accept, because they are not contradictory, although they are irreconcilable; in other words, that there are irreconcilable concepts which are not contradictory, for we always reject one or the other of two contradictory concepts or propositions.

That is so striking an illustration of the mystery of the infinite that I will reproduce it. On a plane imagine a fixed line, pointing north and south. Intersect this at an angle of ninety degrees by another line, pointing east and west. Let this latter rotate at the point of intersection, and at the beginning be a foot long. At each approach of the rotating line toward the stationary line let the former double its length. Let each approach be made by bisecting the angle. At the first movement the angle would be forty-five degrees, and the line two feet in length; at the second, the angle twenty-two and one-half degrees, and the line four feet; at the third, the angle eleven and one-fourth degrees, and the line eight feet; at the fourth, the angle five and five-eighths degrees, and the line sixteen feet; at the fifth, the angle two and thirteen-sixteenths degrees, and the line thirty-two feet, and so on. Now, as this bisecting of the angle can go on indefinitely before the rotating line can touch the stationary line at all its points, it follows that before such contact the rotating line will have a length which cannot be stated in figures, and which defies all human computation. It can be mathematically demonstrated that a line so rotating, and increasing its length in the inverse ratio of its angle with the meridian, will have its end always receding from the meridian and approaching a line parallel to the meridian at a distance of 1.5708. We can show that the rotating line can cross the stationary line by making it do so as on a watch-dial, and yet we can demonstrate that if it be extended indefinitely it can never touch the stationary line, nor come at the end even as near as eighteen inches to it.

Here are two of the simplest human conceptions, between which we know that there is no contradiction, rendered absolutely irreconcilable to the human intellect by the introduction of the infinite. There is no religion here. And yet there is no mystery in either theology or religion more mysterious than the mystery of the infinite, which we may encounter whenever we attempt to set our watches to the right time if they have run more than an hour wrong.

Another error has been the occasion of this cry of "conflict." It is the confounding of "the Church" with "religion." This confusion has led many an honest soul astray, and is the fallacy wherewith shrewd sophists have been able to overthrow the faith of the ignorant. If the Church—and, in all my treatment of this topic, I must be understood as using "the Church," not as signifying "the holy Church universal," but simply in the sense in which antagonistic scientists employ it—if *the Church* and *religion* be the same, the whole argument must be given up, and it must be admitted that there is a conflict between religion and science, and that religion is in the wrong. Churchmen are guilty of helping to strengthen, if indeed they are not responsible for creating, this error. It has at length been presented plumply to the world in the book of Prof. J. W. Draper, entitled a "History of the Conflict between Religion and Science." The title assumes that there is such a conflict. See how it will read with synonyms substituted: "History of the Conflict between *Loving Obedience to God's Word* and *Intelligent Study of God's Works.*" Does Dr. Draper believe there is such a conflict? It is not to be supposed that he does. How, then, did he come to give his book such a title? From a confusion of terms, as will be observed by the perusal of three successive sentences in his preface: "The *papacy* represents the ideas and aspirations of two-thirds of the population of Europe. It insists on a political supremacy, ... loudly declaring that it will accept no reconciliation with modern civilization. The antagonism we *thus* witness between *religion* and science," etc. Now, if "the papacy" and "religion" be synonymous terms, representing equivalent ideas, Dr. Draper's book shows that all good men should do what they can to extirpate religion from the world; but if they are not—and they are not—then the book is founded on a most hurtful fallacy, and must be widely mischievous. Their share of the responsibility for the harm done must fall to churchmen.

No, these are not synonymous terms. "The Church" is *not* religion, and religion is *not* "the Church." There may be a church and no religion; there may be religion and no church, as there may be an aqueduct without water, and there be water without an aqueduct. God makes water, and men make aqueducts. Water was before aqueducts, and religion before churches. God makes religion, and men make churches. There are irreligious men in every church, and there are very religious men in no church. Any visible, organized church is a mere human institution. It is useful for the purpose of propagating religion so long as it confines itself to that function and abstains from all other things. The moment it transcends that limit, it is an injurious institution. In either case it is merely human, and we wrong both religion and the Church when we claim for the latter that it is not a human institution. The Church of England is as much a human institution as the Royal Society; and the same may be said of the Church of Rome and the Royal Florentine Academy. A church is as much an authority in matters of religion as a society is in matters of science, and no more. "The Church" has often been opposed to science, and so it has to religion; but "the society" has often been opposed to religion, and so it has to science. "The Church," both before and since the days of Christ, has stood in opposition to the Bible, the text-book of Jewish and Christian religionists, quite as often as it has to science. But "the society," or "the academy," has stood in opposition to science quite as often as it has to religion. Sometimes the sin of one has been laid upon the other, and sometimes the property of one has been scheduled as the assets of the other. It is time to protest, in the interests of the truth of God, and in the name of the God of truth, that religion no longer be saddled with all the faults of the churchmen, all the follies of the scientists, and all the crimes of the politicians. It was not religion which brought Galileo to his humiliating retraction, about which we hear so much declamation; it was "the Church."

But why should writers of the history of science so frequently conceal the fact that "the Church" was instigated thereunto not by religious people, but scientific men—by Galileo's *collaborateurs?* It was the jealousy of the scientists which made use of the bigotry of the churchmen to degrade a rival in science. They began their attacks not on the ground that religion was in danger, but on such scientific grounds as these, stated by a professor in the University of Padua—namely, that as there were only seven metals, and seven days in the week, and seven apertures in man's head, there could be only seven planets! And that was some time before these gentlemen of science had instigated the sarcastic Dominican monk to attempt to preach Galileo down under the text, *Viri Galilæi, quid statis adspicientes in cœlum?*

In like manner, politicians have used "the Church" to overthrow their rivals. "The Church" is the engine which has been turned against freedom, against science, against religion. It would be as logical and as fair to lay all "the Church's" outrages against human rights and intellectual advancement at the door of religion as it would be to lay all its outrages against religion at the door of science and government, because "the Church" has seldom slaughtered a holy martyr to the truth without employing some forms of both law and logic.

Science exists for the sake of religion, and because of religion. If there had been no love for God in the human race, there had been no study of the physical universe. The visible cosmos is God's love-letter to man, and religion seems to probe every corner of the sheet on which such love is written, to examine every phrase, and study every connection. A few upstarts of the present day, not the real men and masters of science, ignore the fact that almost every man who has made any great original contribution to science, since the revival of letters, was a very religious man; but their weak wickedness must not be charged to science any more than the wicked weakness of ecclesiastics to religion.

Copernicus, who revolutionized astronomy, was one of the purest Christians who ever lived—a simple, laborious minister of religion, walking beneficently among the poor by day, and living among the stars by night; and yet one writer of our day has dared to say, in what he takes to be the interest of science, that Copernicus was "aware that his doctrines were totally opposed to revealed truth." Was anything worse ever perpetrated by theologian, or even ecclesiastic? Could *any* man believe in any doctrine which he *knew* was opposed to any truth, especially if he believed that God had revealed that truth? It were impossible, especially with a man having the splendid intellect and the pure heart of Copernicus, who died believing in his "*De Orbium Cœlestium Revolutionibus*," and also in the Bible. And this is the inscription which that humble Christian ordered for his tomb: "*Non parem Paulo veniam requiro, gratiam Petri neque posco; sed quam in crucis ligno dederis latroni, sedulus oro.*"

Tycho Brahe, who, although he did not produce a system which won acceptance, did, nevertheless, lay the foundation for practical astronomy, and build the stairs on which Kepler mounted to his grand discoveries, was a most religious man. He introduces into one of his scientific works ("*Astronomiæ Instauratio Mechanica*," p. A) this sentence: "No man can be made happy, and enjoy immortal life, but through the merits of Christ, the Redeemer, the Son of God, and by the study of his doctrines, and imitation of his example."

John Kepler was a man in whose life the only conflict between science and religion seemed to be as to which should yield the most assistance to the other. He wrought as under Luther's motto, "*Orasse est studisse.*" He prayed before he worked, and shouted afterward. The more he bowed his soul in prayer, the higher his intellect rose in its discoveries; and, as those discoveries thickened on his head, it bowed in humbler adoration. And so that single man was able to do more for science than all the irreligious scientists of the last three centuries have accomplished, while he bore an appalling load of suffering with a patience that was sublime, and, dying, left this epitaph for his tombstone: "*In Christo pie obiit.*"

Of Sir Isaac Newton's, and Michael Faraday's, and Sir William Hamilton's, and Sir James Y. Simpson's religious life, not to mention the whole cloud of witnesses, we need not tell what is known to all men. But the history of science shows that not the most gifted, not the most learned, not the most industrious, gain the loftiest vision, but that only the pure in heart see God. And all true science is a new sight of God.

Herbert Spencer says: "Science may be called an extension of the perceptions by means of reasoning" ("Recent Discussions," p. 60). And we may add, religion may be called an extension of the perceptions by means of faith. And having so said, have we not paraphrased Paul? "Faith is confidence in things hoped for, conviction of things not seen" (Heb. xi. 1). Science has the finite for its domain, religion the infinite; science deals with the things seen, and religion with the things not seen. When Dr. Hutton, of Edinburgh, announced, in the last century, "In the economy of the world I can find no traces of a beginning, no prospect of an end," it is said that scientific men were startled and religious men were shocked. Why should they be? The creation of the universe and its end are not questions of science, and can be known only as revealed to faith. And so Paul says: "Through faith we apprehend intellectually that the worlds have been framed by the word of God, so that that which is seen may have sprung from that which is not seen" (Heb. xi. 3).

PLASTICITY OF INSTINCT.

BY GEORGE J. ROMANES.

NOW that the doctrine which is maintained by Mr. Douglass A. Spalding on this subject has proved itself so completely victorious in overcoming the counter-doctrine of "the individual-experience psychology"—and this along the whole line both of fact and theory—it seems unnecessary for any one to adduce additional facts in confirmation of the views which Mr. Spalding advocates.[1] I shall therefore confine myself to detailing a few results yielded by experiments which were designed to illustrate the subordinate doctrine thus alluded to in Mr. Spalding's article:

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[1] *See* POPULAR SCIENCE MONTHLY for January, 1876.

"Though the instincts of animals appear and disappear in such seasonable correspondence with their own wants and the wants of their offspring as to be a standing subject of wonder, they have by no means the fixed and unalterable character by which some would distinguish them from the higher faculties of the human race. They vary in the individuals as does their physical structure. Animals can learn what they did not know by instinct, and forget the instinctive knowledge which they never learned, while their instincts will often accommodate themselves to considerable changes in the order of external events. Everybody knows it to be a common practice to hatch duck's-eggs under a common hen, though in such cases the hen has to sit a week longer than on her own eggs. I tried an experiment to ascertain how far the time of sitting could be interfered with in the opposite direction. Two hens became broody on the same day, and I set them on dummies. On the third day I put two chicks a day old to one of the hens. She pecked at them once or twice, seemed rather fidgety, then took to them, called them to her, and entered on all the cares of a mother. The other hen was similarly tried, but with a very different result. She pecked at the chickens viciously, and both that day and the next stubbornly refused to have anything to do with them," etc.

It would have been well if Mr. Spalding had stated whether these two hens belonged to the same breed; for, as is of course well known, different breeds exhibit great variations in the character of the incubatory instinct. Here, for instance, is a curious case: Spanish hens, as is notorious, scarcely ever sit at all; but I have one purely-bred one, just now, that sat on dummies for three days, after which time her patience became exhausted. However, she seemed to think that the self-sacrifice she had undergone during these three days merited some reward, for, on leaving the nest, she turned foster-mother to all the Spanish chickens in the yard. These were sixteen in number, and of all ages, from that at which their own mothers had just left them up to full-grown chickens. It is remarkable, too, that although there were Brahma and Hamburg chickens in the same yard, the Spanish hen only adopted those that were of her own breed. It is now four weeks since this adoption took place, but the mother as yet shows no signs of wishing to cast of her heterogeneous brood, notwithstanding some of her adopted chickens have grown nearly as large as herself.

The following, however, is a better example of what may be called plasticity of instinct: Three years ago I gave a pea-fowl's egg to a Brahma hen to hatch. The hen was an old one, and had previously reared many broods of ordinary chickens with unusual success even for one of her breed. In order to hatch the pea-chick she had to sit one week longer than is requisite to hatch an ordinary chick, but in this there is nothing very unusual, for, as Mr. Spalding observes, the same thing happens with every hen that hatches out a brood of ducklings.[1] The object with which I made this experiment, however, was that of ascertaining whether the period of maternal care subsequent to incubation admits, under peculiar conditions, of being prolonged; for a pea-chick requires such care for a very much longer time than does an ordinary chick. As the separation between a hen and her chickens always appears to be due to the former driving away the latter when they are old enough to shift for themselves, I scarcely expected the hen in this case to prolong her period of maternal care, and indeed only tried the experiment because I thought that if she did so the fact would be the best one imaginable to show in what a high degree hereditary instinct may be modified by peculiar individual experiences. The result was very surprising. For the enormous period of eighteen months this old Brahma hen remained with her ever-growing chicken, and throughout the whole of that time she continued to pay it unremitting attention. She never laid any eggs during this lengthened period of maternal supervision, and, if at any time she became accidentally separated from her charge, the distress of both mother and chicken was very great. Eventually the separation seemed to take place on the side of the peacock; but it is remarkable that, although the mother and chicken eventually separated, they never afterward forgot each other, as usually appears to be the case with hens and their chickens. So long as they remained together the abnormal degree of pride which the mother showed in her wonderful chicken was most ludicrous; but I have no space to enter into details. It may be stated, however, that both before and after the separation the mother was in the habit of frequently combing out the top-knot of her son—she standing on a seat, or other eminence of suitable height, and he bending his head forward with evident satisfaction. This fact is particularly noteworthy, because the practice of combing out the top-knot of their chickens is customary among pea-hens. In conclusion, I may observe, that the peacock reared by this Brahma hen turned out a finer bird in every way than did any of his brothers of the same brood which were reared by their own mother, but that, on repeating the experiment next year with another Brahma hen and several pea-chickens, the result was different, for the hen deserted her family at the time when it is natural for ordinary hens to do so, and in consequence all the pea-chickens miserably perished.

I have just concluded another experiment which is well worth recording: A bitch ferret strangled herself by trying to squeeze through too narrow an opening. She left a very young family of three orphans. These I gave, in the middle of the day, to a Brahma hen which had been sitting on dummies for about a month. She took to them almost immediately, and remained with them for rather more than a fortnight, at the end of which time I had to cause a separation, in consequence of the hen having suffocated one of the ferrets by standing on its neck. *During the whole of the time that the ferrets were left with the hen the latter had to sit upon the nest;* for the young ferrets, of course, were not able to follow the hen about as chickens would have done. The hen, as might be expected, was very much puzzled at the lethargy of her offspring. Two or three times a day she used to fly off the nest, calling upon her brood to follow; but, upon hearing their cries of distress from cold, she always returned immediately and sat with patience for six or seven hours more. I should have said that it only took the hen one day to learn the meaning of these cries of distress; for after the first day she would always run in an agitated manner to any place where I concealed the ferrets, provided that this place was not too far away from the nest to prevent her from hearing the cries of distress. Yet I do not think it would be possible to conceive of a greater contrast than that between the shrill peeping note of a young chicken and the hoarse growling noise of a young ferret. On the other hand, I cannot say that the young ferrets ever seemed to learn the meanings of the hen's clucking. During the whole of the time that the hen was allowed to sit upon the ferrets she used to comb out their hair with her bill, in the same way as hens in general comb out the feathers of their chickens. While engaged in this process, however, she used frequently to stop and look with one eye at the wriggling nest-full with an inquiring gaze expressive of astonishment. At other times, also, her family gave her good reason to be surprised; for she used often to fly off the nest suddenly with a loud scream—an action which was doubtless due to the unaccustomed sensation of being nipped by the young ferrets in their search for the teats. It is further worth while to remark that the hen showed so much uneasiness of mind when the ferrets were taken from her to be fed, that at one time I thought she was going to desert them altogether. After this, therefore, the ferrets were always fed in the nest, and with this arrangement the hen was perfectly satisfied—apparently because she thought that she then had some share in the feeding process. At any rate she used to cluck when she saw the milk coming, and surveyed the feeding with evident satisfaction.

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[1] The greatest prolongation of the incubatory period I have ever known to occur was in the case of a pea-hen which sat very steadily on addled eggs for a period of four months, and had then to be forced off in order to save her life.

Altogether I consider this a very remarkable instance of the plasticity of instinct. The hen, it should be said, was a young one, and had never reared a brood of chickens. A few months before she reared the young ferrets she had been attacked and nearly killed by an old ferret which had escaped from his hutch. The young ferrets were taken from her several days before their eyes were open.

In conclusion I may add that, a few weeks before trying this experiment with the hen, I tried a similar one with a rabbit. In this case the ferret was newly born, and I gave it to a white doe-rabbit which had littered six days before. Unlike the hen, however, she perceived the imposture at once, and attacked the young ferret so savagely that she broke two of its legs before I could remove it. To have made this experiment parallel with the other, however, the two mothers ought to have littered on the same day. In this case the result would probably have been different; for I have heard that under such circumstances even such an intelligent animal as a bitch may be deceived into rearing a cat, and *vice versa.*—*Nature.*

FLYING-MACHINES AND PÉNAUD'S ARTIFICIAL BIRD.[1]

TRANSLATED FROM THE JOURNAL DE PHYSIQUE,

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NUMEROUS attempts have been made at different times to construct a machine capable of propelling itself through the air. All kinds of aërial propellers have in turn been tried; such as screws, beating wings, umbrellas which open and shut during their reciprocating motion, inclined planes, aërial wheels. But though many of these projects called forth considerable inventive ability, yet, until quite recently, the *helicopteron* (from ἑλικός, any thing spiral or twisted, and πτερόν, a wing—that is, a machine furnished with an aërial screw-propeller) was the only type of machine which had succeeded in raising itself in flight. Several of these helicopterons have been constructed since 1784, at which date Bienvenu made the first that flew. The best known and the most perfect was that which Ponton d'Amécourt constructed in 1864, and which raised itself for a moment by a sudden motion to a height of two and a half metres. It was formed of two superposed right and left handed screws, put in motion by a watch-spring. All other methods of artificial flight, including those of propellers with wings beating the air like those of a bird, remained ineffective, and were the subjects of conflicting hypotheses as to the nature of flight.

In beginning our studies, we have thought that the best means of getting rid of the multiplicity of hypotheses and of conflicting opinions would be to divide the flying-machines that have been invented into a small number of general types; then to reduce each of these types to its essential elements, and finally to design a flying-machine of each of these simplified types possessing all the really essential parts, and easy to construct.

Leaving out of consideration the inventions which are evidently defective, we have thought it possible to divide the majority of the systems of artificial flight into *helicopterons*, *areoplanes*, and *orthopterons* (from ὀρθός, straight, and πτερόν, a wing). The helicopterons sustain themselves by the aid of screws whose axes of rotation are nearly vertical. They may be made to progress either by these vertical screws or by special screw-propellers. The areoplanes have propelling surfaces which are nearly plane and slightly inclined to the horizon. A horizontal motion is given to these surfaces generally by means of screws. Finally, in the orthopterons, the propelling organs are surfaces moving in vertical directions, and generally having reciprocating motions. In this system are embraced the wings of birds and the moving surfaces of the tails of fishes.

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[1] The Academy of Sciences of Paris, at its meeting in June, 1875, awarded to M. Pénaud a prize for the discoveries and inventions described in this article.

The knowledge of the resistance of the air appeared to us the only guide by which we could arrive at a thorough understanding of the manner in which a machine could sustain itself by the actions of its propelling surfaces on this fluid. We entered upon an attentive study of several imperfectly-understood points appearing to us of capital importance; such as the sustaining screw, the aërial inclined plane, and the theory of the equilibrium of flying-machines. The screw-propeller was well understood from its effects in propelling vessels. These researches, which led us to a small number of very simple general laws, permitted us to determine the manner of action and the proportions of the machines which we desired to construct.

It remained to find a motor the easiest of application. Wood, whalebone, and steel, give forces which are at a minimum when referred to their weight; caoutchouc is much more powerful, but the framework necessary to resist its violent tension is necessarily quite heavy. We then conceived the idea of using the elasticity of the torsion of caoutchouc, which finally led to an easy, simple, and effective method of constructing the models of flying-machines.

We applied the new motor first to the helicopteron, after having previously investigated the curious and valuable actions of caoutchouc when subjected to various successive torsions. In April, 1870, we presented models to M. de la Landelle which rose in flight to more than fifteen metres, hovering and fluttering through large inclined circles, and sustaining themselves during more than twenty seconds.

The great superiority of these results over those obtained with preceding helicopterons encouraged us to apply our motor to other systems of artificial flight. On the 18th of August, 1871, in the presence of the Society of Aërial Navigation, we succeeded in making an areoplane fly with various velocities and in different directions, around one of the circles of the garden of the Tuileries. The success of this machine in its ascending motions and in its perfect equilibrium gave the first successful exhibition of a machine on the areoplane type.

Measured directly, and irrespective of any hypothesis, the force required to sustain and propel the areoplane and the helicopteron proved to be relatively moderate, and did not approach the fabulous estimations previously given by Navier. This experiment demonstrated that the muscular strength of birds, although notably greater, for equal weights, than that of mammals, did not exceed a reasonable estimation.

Our helicopterons and areoplanes which performed with success on the 2d of July, 1875, before the Physical Society, have a numerous offspring. They have been imitated with various success by Crocé-Spinelli and MM. Montfallet, Pétard, and Tantin.

The action of these machines, in fully confirming our ideas and calculations on the resistance of the atmosphere, encouraged us to attempt the construction of a mechanical bird with flapping wings. The diversity of the hypotheses as to the nature of flight, proposed in France and in England, though bearing witness to the difficulties to be met with in the construction of this mechanism, yet rendered the problem peculiarly interesting.

The experiments heretofore made with mechanical birds had been very discouraging. M. Artingstall and M. Marey had alone obtained effective results. M. Artingstall states that, some thirty years since, he had an artificial bird which flew at the end of a tube jointed on to a steam-boiler. M. Marey, whose beautiful physiological experiments are so well known, constructed, in 1870, artificial insects which, attached to a radial tube carrying a counterpoise equal to two-thirds of their weight, rose and flew in a circle by the aid of their wings. The compressed air which set the wings in motion was conveyed to them through the radial tube from a compression-pump worked by hand.[1] It remained to gain the two-thirds of the weight of the insect and to cause the latter to carry with it its motor instead of having the wings moved by a force conveyed to the insect from without.

Encompassed by the divers hypotheses of the action of the wing given by Borelli, Huber, Dutrochet, Strauss-Durckeim, Liais, Pettigrew, Marey, d'Esterno, De Lucy, Artingstall, etc., and in view of the very complicated motions they had assigned to that organ and to each of its quills—motions which are, for the most part, inimitable in a mechanical bird—we decided to reason out for ourselves, by relying on the laws of the resistance of the air and on some of the most simple facts of observation, what are *the motions of the wing really neccssary to flight.* We found—1. *A double oscillation*, a depression, and an elevation of the wings transverse to the path of flight. 2. The change of the plane of the same during this double motion; the lower surface of the wing facing below and behind during its depression, so as to sustain the bird, the same surface of the wing facing below and in front during its elevation, so that the wing is raised with the least resistance by cutting the air with its edge while the bird flies. These movements, moreover, were admitted to be correct by a large number of observers, and have been concisely demonstrated by Strauss-Durckeim, Liais, and Marey.

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[1] *See* Fig. 87, on page 202 of Marey's "Animal Mechanism," published in the "International Scientific Series."

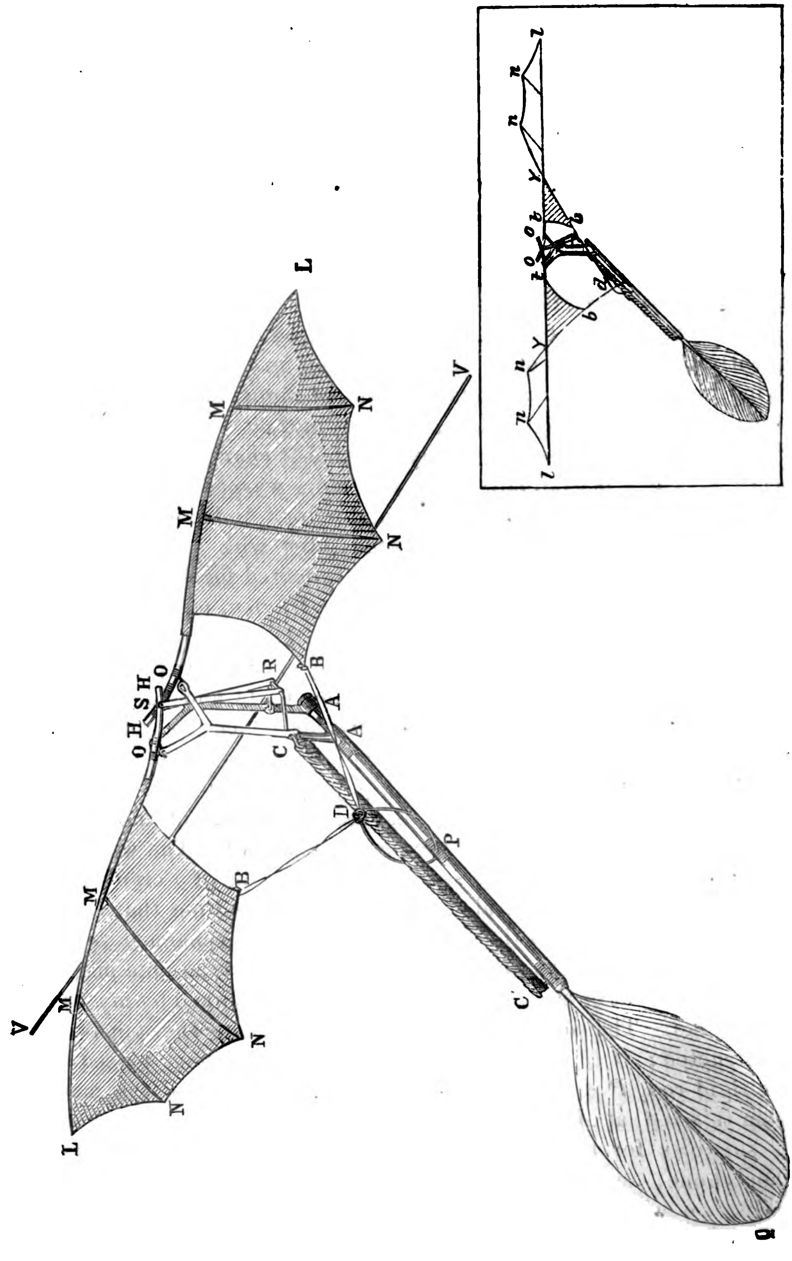
But, in considering the difficulty of the construction of our mechanical bird, we were obliged, notwithstanding our desire to make a machine which should be simple and easy to understand, to try to perfect those actions we have somewhat summarily described. It is evident that the different parts of the wing, from its base to its extremity, act on the air under very different conditions. The interior part of the wing, having small velocity, produces little propelling effect at any moment of its beat; but it is far from being useless, and one may imagine how, by presenting its lower face downward and slightly facing the front, it acts during the rapid translation of the bird, like a kite, as well while the wing is being elevated as during its downward motion, and thus sustaining in a continuous manner a portion of the weight of the bird. The middle portion of the wing has a junction intermediate between that of the interior and that of the outer portion, or end, of the wing; so that the wing, during its action, is twisted on itself in a continuous manner from its base to its extremity. The plane of the wing at its base varies but little during flight; the plane of the median part of the wing is very much displaced on one and the other side of its mean position; finally, the outer part of the wing, and especially its tip, experiences considerable change of plane. This warping of the wing is modified at each instant during its elevation and depression, in the manner just indicated; at the extreme points of its beat the wing is nearly plane. The action of the wing is thus seen to be intermediate between that of an inclined plane and that of a screw with a very long and continually variable pitch.

Notwithstanding the differences found to exist in the hypotheses of various authors when compared with one another and with the one just given, still one or the other of these writers confirms the greater portion of the ideas just advanced. Thus the torsion of the wing had already been pointed out by Dutrochet, and especially by Pettigrew, who long maintained this opinion; only he has taken, according to our view, the change of form occurring during the elevation of the wing for that of the form occurring during its depression, and *vice versa*. These authors clearly saw how the articulations of the bones, the ligaments of the wing, the imbrication and elasticity of the quills, bring about the above result. M. d'Esterno had explained the continuous effect, like that of a kite, of the interior portion of the wing during its depression and elevation; and M. Marey had very appropriately designated that portion of the wing as "passive," at the same time, however, maintaining that the most important action of the wing during flight is due to a general change of its plane produced by the rotation of the humerus on itself.

According to our view there is a sharp distinction to be made between hovering and the ordinary flight of progression, while the amplitude of the changes in the plane of the extremity of the wing is essentially a function of the velocity of translation of the bird. At the extremity of the wing, where the most considerable changes of plane takes place, these changes equal 90°, and even more, during hovering; but then displacements of plane are far less in the flight of progression. According to our calculations the extreme portions of the surface of the terminal feathers of the crow's wing are, during free flight, inclined forward during the depression of the wing only from 7° to 11° below the horizontal, and from 15° to 20° above the horizontal plane during the elevation of the wing. The plane of the wing at its base acts during the above motions like a kite inclined at an angle only of from 2° to 4°.

It is easy to verify the slight inclination of the wing, and consequently the smallness of its angles of action in the air, by observing a flying bird moving in an horizontal line of sight, for we then see only the edges of the wings. It is, in short, inexact to say that the wing changes its *plane;* we can barely say that it changes its *planes.* The truth is, that it is gradually more and more warped in going from its base to its extremity. It was so understood, indeed, by an English author, whose labors we became acquainted with after we had constructed our bird, and to him we are indebted for having saved us several researches. The theory of Sir G. Cayley, published in 1810, differs from ours but in a few particulars. He is of the opinion that the outer portion of the wing in ascending exerts always a propulsive action, and he attributes to the propelling parts and to the sustaining, kite-like parts of the wing, proportions which are relatively the reverse of those to which we have been led by our calculation.

It was with these ideas, favorably judged of by the Academy in September, 1871, that we undertook the application of the torsion of caoutchouc to the problem of the mechanical bird. The wings of our bird are made to beat in the same plane by means of a crank and connecting rods. After several rough trials, we found out that the transformation of motion in the machine required a mechanism very solid relatively to its weight, and I requested M. Tobert, an able mechanist, to construct out of steel a piece of mechanism designed by my brother, E. Pénaud. The accompanying figure represents the apparatus so constructed; *C C′* is the motor of twisted caoutchouc placed above the rigid rod, *P A A*, which is the vertebral column of the machine; from this rod, at *A* and *A*, ascend two rigid forks, which serve below as supports for the crank, *C R*, which is attached to the twisted caoutchouc; and above, at the ends of the forks at *O* and *O*, are the pivots on which the wings oscillate. The links, *R S*, convert the motion of rotation of the crank into the reciprocating motion of the arms, *O M L*, *O M L*. At *Q* is a steering-tail, which we found by experience was best made from one of the long feathers of a peacock's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tail, and which can be inclined upward, or downward, or to one side, and be loaded with wax so that the centre of gravity of the machine can be brought to the proper position.

The warping of the wings, *O L*, is obtained by the mobility of the wing and of the little fingers, *M N*, supporting them on the large rods, *O M L*, which do not partake of this rotation. A little ligament of caoutchouc, *D B*, connects the posterior interior angles of the wings with the middle of the central rod of the machine. This ligament, whose function is similar to that of the posterior paws of the bat, plays the part of an elastic sheet to our wing, so closely resembling the topsail of a schooner. The torsions of the wing are thus automatically regulated, as required, by the combined action of the pressure of the air and of this elastic ligament. The interior third of the surface of the wing acts like a kite during the elevation as well as during the depression of the wing. The external two-thirds, corresponding to the primary and secondary quills of birds, propel and sustain the machine during the downward motions of its wings. The little drawing in the corner shows the wings just about to begin their downward beat. During the elevation of the wing the terminal feathers conform to the sinusoidal track along which they progress in the air; it thus only cuts the atmosphere without acting against it. To start the machine, we simply abandon it to itself in the air.

This machine was exhibited before the Society of Aërial Navigation on the 2d of June, 1872, and flew several times more than seven metres—the length of the public hall—raising itself in a continuous manner, with an accelerated velocity, along a line of flight inclined 15° to 20°. In an open space, the artificial bird flew over twelve to fifteen metres, elevating itself during this flight to about two metres. Another model, exhibited before the same society in October, 1874, flew in an horizontal line, vertically upward, and also ascended obliquely.

On the 27th of last November, at a public exhibition, this model flew from one end to the other of the hall of the Horticultural Society (*see Aëronaute*, February, 1875). On the 2d of July, 1875, it performed with success before the French Physical Society. The velocity of its flight is from five to seven metres per second.

The birds of twisted caoutchouc have been a great success.

M. Hureau de Villeneuve, whose zeal in the study of aërial navigation is well known, and who in his many contributions to the theory of flight since 1868 has discussed the inclination to the horizon of the axes of the scapulo-humeral articulations and their posterior convergence, exhibited, on the 20th of June, 1872, a bird moved by twisted caoutchouc, which, he states, elevated itself vertically to a height of nearly one metre. Continuing his researches with perseverance, he again exhibited his apparatus before the Society of Aërial Navigation on the 13th of January, 1875, after having supplied it with wings similar to those of my bird, and after having adopted several of the peculiarities which had made my machine successful. He then succeeded in giving sustained flight to his machine, which we have ourselves seen fly horizontally nearly seven metres, after having been started by a slight impulse from the hand. M. Tatin, also, in 1874, made two very curious artificial birds, using twisted caoutchouc as a motor. M. Marey has told us that he saw the first named fly in his garden, last November, from eight to ten metres. We have seen the second, nearly identical with our bird, fly in a still more satisfactory manner.

A MUSEUM EXCHANGE.[1]

By Prof. BURT G. WILDER.

THERE are in this country three institutions more or less available for the distribution of material for Natural History instruction: the Smithsonian Institution at Washington, District of Columbia; the (Agassiz) Museum of Comparative Zoölogy, at Cambridge, Massachusetts; and Prof. Ward's establishment at Rochester, New York.

The first is especially rich in American forms, the collections of government surveys, and the types of Baird's descriptions. There are many duplicates, but these are required for the elucidation of the extent of variation within the species, so that they are available for exchanges in only a limited degree.

The peculiar value of the Cambridge Museum comes from the immense amount of material from all parts of the world, upon which zoölogists are enabled to pursue extended investigations, either at the museum, or, under certain conditions, elsewhere.

Agassiz also desired to prepare collections for educational institutions in Massachusetts, and to provide for teachers an opportunity for summer instruction and for the collection of specimens.

But it is evident that the above-mentioned establishments and arrangements are not yet able to meet a rapidly-growing want of the whole country; namely, the *immediate formation of museums* for the illustration of the courses in natural history which are now generally demanded, in not only the colleges and universities (whether real or so called), but also the normal schools, and even those of lower grade.

Such selected collections need not be either very large or very costly. They should embrace mainly *typical* forms, but contain also some of the peculiar or aberrant species of each large group.

It would be well if some one would make out a list of what are desirable in larger or smaller collections. Meantime, the information and the material are, to a great extent, obtainable from the catalogues and the museum of Prof. Ward.

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[1] Presented at the Detroit meeting of the American Association for the Advancement of Science.

A recent examination of this establishment has suggested a brief sketch of its nature, its capacity for supplying the want above indicated, and of the additions which might advantageously be introduced.

Prof. Ward was a pupil of Agassiz, and afterward Professor of Natural History in Rochester University, where he formed a very extensive and well-arranged museum of geology, mineralogy, paleontology, and zoölogy. Desiring to include with this fac-similes of unique fossils in other museums, Prof. Ward spent three years in Europe, and gradually accumulated moulds of famous fossils. The great expense of this undertaking (nearly $20,000) determined him to make duplicates of the casts, and thus, by degrees, originated the now well-known "Ward Series of Casts of Fossils;" and at present, in many of our educational institutions, large and small, the megatherium, iguanodon, ichthyosaurus, and pterodactyl have become as familiar forms as the professors themselves.

The usefulness of this branch of the establishment is now generally recognized, and, with the mineralogical department, has been graphically described by others,[1] so we may pass to the consideration of what has been and may be accomplished by Prof. Ward for the furnishing of zoölogical museums.

At present, mounted insects and stuffed birds receive but little of his attention, but the collections embrace representatives of the leading groups of the whole animal kingdom, more than 13,000 species being represented. The echinoderms and crustacea, being easily preserved in a dry state, are very numerous. They have recently been carefully rearranged and determined by a professional naturalist.

Prof. Ward keeps twenty-two advertisements in foreign journals, and has correspondents in all parts of the globe, near and remote, so that scarcely a week passes without his receiving word of the sending to him of rare forms.

At the time of our visit he was receiving the results of a late trip to Europe (where he had expended about $10,000 for specimens). On the same day arrived the skins and skeletons of two camels, the one from Asia Minor, the other from Turkey. The taxidermists were engaged upon a grizzly bear, a 1,000-pound turtle, and the now-famous donkey which slew a lion in Cincinnati; while the osteologists were mounting a whale's skeleton for the Peabody Academy of Science at Salem, Massachusetts, and would then commence upon a large series of skeletons for the Smithsonian Institution.

A specimen of the rare tiger-shark (*Crossorhinus dasypogon*) had just arrived from Australia.

Ten men are constantly employed in the reception and arrangement of these specimens, in the preparation of skins and the mounting of skeletons. The chief osteologists and taxidermists were brought from Europe, and their salaries are more than is received by many an assistant professor.

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[1] As by Prof. E. S. Morse, in the *American Naturalist* for April, 1873, and Prof. Alexander Winchell, in the *College Courant* for October 1, 1870.

In alcohol are fishes and reptiles, such as the *Lepidosteus*, *Polyodon*, and *Amia*, of our Western rivers, the *Calamoichthys* of Africa, the *Siren* and *Amphiuma* of South Carolina, and the *Proteus* of Europe; while in dry, upper rooms hang hundreds of skins of quadrupeds, large and small, from all parts of the world, and carefully labeled.

The excellence and trustworthiness of the work done by Prof. Ward are further attested by the extent to which he is employed by the Smithsonian Institution, the Cambridge Museum, and others both here and abroad. Indeed, it is no unusual thing for material to come from Europe to Rochester, and be returned to some Continental museum.

But, while gladly commending what is done, we would offer a suggestion as to what might be done with great advantage to our educational institutions and a fair profit to Prof. Ward:

1. Such an establishment should supply the lower vertebrates, the *lamprey* and particularly *amphioxus*, of which, also, sections might be prepared for the microscope.

2. There should be kept, or prepared to order, series of *embryos* of some common animals: among mammals the pig, and among batrachians the frog, are very easily obtained. All *embryos* are, in some respects, more valuable than adults, and, if they were on hand, a demand would surely arise.

3. A series of brains should be added. The models of these, whether plaster or *papier-maché*, are poor substitutes for the real specimens. Nor need the number be very large; a dozen species would fairly illustrate the modifications of the vertebrate encephalon.

Speaking of brains, we cannot forbear expressing the hope that Prof. Ward may shortly be able to impress his clients with the truth of Prof. Wyman's saying that "a skull is doubled in value by cutting in two." The inside is quite as important as the outside, while such vertical bisection, if carefully made, enables us to secure the two halves of the brain but little injured.[1]

4. Other anatomical preparations of soft parts, sections and dissections, are really desired for instruction, and a few typical preparations could readily be made.

5. Finally, we would suggest to Prof. Ward the expediency of

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[1] A case in point occurs while correcting the proof of this article. Prof. Ward has received a "blackfish" (*Elobiocephalus melas*). Knowing that the Cornell University would like the brain, he sends me word; but, as the section of the skull for extraction of the brain would impair its value for most purchasers, we have to take the whole skeleton also. The brain, by-the-way, weighs nearly five pounds, two pounds more than the average human brain, and nearly a pound more than that of Cuvier.

making his establishment a medium of exchange between parties in different localities. For instance, A lives in Central New York; he has plenty of *Menobranchus*, and would exchange them for *Menopoma* from the Ohio River, or the gars and spoonbills of the Mississippi, of which B has more than he wants; while both these parties desire sharks, and skates, and pipe-fishes, and the large lamprey from the seacoast where C lives. To purchase and keep all these and many more such on hand involves an enormous expense and risk to a single individual; whereas, if, under certain conditions, Prof. Ward received good specimens of these forms, and stored them at the owner's risk as to fire, and expense as to alcohol, etc., then he could, at a fair commission, transfer them to those who desired them without the expenditure now incurred.

The arrangement could be made like that of the naturalists' agency for books in Salem, Massachusetts, and a periodical list of specimens and prices could be issued. The prices would serve as guides for either exchange or direct purchase.

Such a system of transfer would, it seems to us, not only enable new institutions to rapidly form type collections for class-room instruction, but also encourage them to collect large numbers of duplicates of the forms peculiar to their localities. In this way we should ascertain the extent of individual variation, the manner and rate of development and growth, and, by preparations made on the spot, the structure of the brains and other soft parts, which are seldom perfectly preserved in specimens sent in alcohol from a distance.

ARE THE ELEMENTS ELEMENTARY?

By F. W. CLARKE,

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WHAT are the so-called chemical elements? Are they really elements, or only compounds of remarkable stability? It would be hard to find in physical science a question which has been oftener asked than this. It has furnished all sorts of investigators with abundant food for speculation. Men of the highest scientific ability have grappled with the problem, and left it still unsolved; others have constructed elaborate theories, which claimed to settle everything. Still the debate goes on. We cannot prove that the elements are truly what we call them, nor can we show beyond all doubt that they are compound in their nature. We may, however, weigh the opposing probabilities, and see which side of the question is the stronger. Whichever way the balance turns, the superstructure of chemistry will be but little affected. We know that all our recognized compounds are formed by the union together of two or more supposed elements; and no revelations concerning the nature of the latter can well disturb that established knowledge. However we may speculate, the experimentally-ascertained facts will remain unaltered. They may receive slightly different theoretical interpretations, without having their practical bearings changed in the least degree.

The prevalent view of the subject, that the elements are elementary, is held by philosophical chemists in a purely provisional way. We need a convenient working hypothesis, and these sixty-three substances are elements for aught we absolutely know to the contrary. As far as we are at present experimentally concerned, then, we call them elements, bearing always in mind the possibility that they may be compounds. They have never been decomposed; we have no means adequate to their analysis; not one of them can be obtained from materials in which it does not already exist. But all this evidence is only negative. How do we know but that some future discovery may render possible the decomposition of these supposed elements? Shall we assert positively that we have reached the ultimate analysis, and may never hope to go any farther? Obviously, so definite a statement would be unjustifiable, and no sane chemist would venture to make it. The uncertainty of the subject may well be illustrated by a reference to chemical history. At the beginning of the present century the alkalies and alkaline earths were thought to be elements. They were not decomposable by any means then known, so that the supposition was perfectly fair. A very few years passed away, the galvanic battery was brought into use, and presently it was found that each of these bodies was a compound, containing a metal united with oxygen. Perhaps a similar advance in our knowledge may demonstrate the possibility of decomposing many of the substances now regarded as elementary. Such a discovery might work in either one of three ways. It might largely increase the number of supposed elements, by dividing each one into two or more new bodies. It might reduce the number by proving that our elements were formed by the union, in various proportions, of only a very few simpler substances. Or it might demonstrate the unity of matter, just as recent science has demonstrated the unity of force, and give us only one true element underlying all material forms. Such a culmination of our knowledge would be grand, indeed!

The evidence, then, upon which we assert the elementary nature of the fifty metals and thirteen non-metals, is very incomplete. On this side of the question there is really no other important testimony, save that just cited. Arguing from our present inability to decompose certain bodies, we assume for convenience that they are indecomposable. Now let us see what there is in favor of the opposite view.

One of the first things learned by the student in chemistry is, that the so-called elements are readily classifiable into a few natural groups.

The members of any one of these groups resemble each other chemically in the closest manner, forming compounds of strong similarity, and often are very much alike in their physical properties also. The thought at once arises, Can these elements be totally distinct from each other—have they nothing in common—are these resemblances only due to chance? Such a supposition could scarcely be admitted, since Science excludes chance from her list of natural agencies. These relationships must mean something—but what?

If we look beyond the points of similarity to the points of difference between related elements, we shall find that these too are subject to regularity. The members of a group vary from each other, not in a meaningless, helter-skelter way, but systematically, so that they may be arranged in regular series. Take, for example, the group formed by the strikingly similar metals, calcium, strontium, and barium. If, now, we compare these with reference to any physical property, we shall find that strontium will always be between the other two. It is heavier than calcium and lighter than barium; and the same thing holds true of strontium compounds when compared with the corresponding compounds of its two associates. The integrity of the series is perfect; for in no case can the middle member be placed either at the beginning or the end. The nitrogen group is even more remarkable. Arranging its recognized members in the order of their atomic weight, they are as follows: nitrogen, phosphorus, arsenic, antimony, and bismuth. The first of these elements is gaseous at all known temperatures; phosphorus is a solid, but easily convertible into a gas by heat; arsenic is a denser body still, and less readily vaporized; antimony follows in regular order; and finally, bismuth, the heaviest of the series, can be distilled only with considerable difficulty. Here, then, is a gradation both in specific gravity and in boiling-point, the lowest member of the group, in each of these particulars, being that with the lowest atomic weight; and the reverse. If we ascend from these elements to their compounds, we shall also notice some curious chemical regularities. Each member of the group unites with oxygen to form a pentoxide, from which an acid may be derived. Compare, now, these five acids: nitric is very strong, and violently corrosive; phosphoric is a little weaker, and acts much less vigorously; arsenic is feebler still; antimonic is extremely weak; and the corresponding bismuth compound is just barely recognizable as being an acid at all. Can these regular gradations be purely accidental and meaningless?

Examples like these might be adduced almost indefinitely. Series after series could be brought forward, all illustrating the same principle. Exceptions occur now and then, but they are so few that for present purposes they may be disregarded. Of course they mean something, but they are neither sufficiently abundant nor important enough to affect our arguments. The regularities are so numerous and so remarkable as to outweigh many times over all seeming variations. All this evidence is, however, inadequate in one respect: the relations thus far pointed out cannot be simply expressed in figures. Are there, then, any numerical relations connecting the elements? This question may be answered, partly by studying their atomic weights, and partly by an examination of their specific volumes.

The regularities which connect the elementary atomic weights have been examined and discussed by many investigators from widely differing points of view. Some chemists have contented themselves with the naked facts; others have considered the bearing of those facts upon chemical theories; and a third class, with less caution than ignorance, have speculated upon them in the wildest and most reckless manner. Of course a full summary of the whole subject, however interesting it might prove, would be out of place in a condensed argument like this. All we can do here is to glance at a few of the many relations known, and afterward consider them in their connection with our main subject. The general reader who cares to go deeper into the question will do well to consult the original papers of Dumas, Gladstone, J. P. Cooke, Kremers, Mendelejeff, and others.

Of the relations now under consideration, the one most frequently cited is as follows: Many elements are most naturally arranged in threes, of which the middle member has an atomic weight very nearly a mean between the atomic weights of the other two. Thus we have calcium, atomic weight, 40; strontium, 87.5; and barium, 137. Here, if the value of strontium were 88.5, it would be an exact mean. Again, chlorine has the atomic weight 35.5; bromine, 80; and iodine, 127; the second being almost precisely midway between the first and third. A still closer agreement with theory is furnished by lithium, sodium, and potassium, whose values are respectively 7, 23, and 39.1. A fourth example is afforded by potassium, 39.1; rubidium, 85.4; and cæsium, 133; while a fifth case is offered by phosphorus, 31; arsenic, 75; and antimony, 122. To be sure, these illustrations afford only an approximation to regularity; but then the variations are themselves somewhat regular. In each of these twos the middle term is just a little too low to be an absolute mean between its associates; that is, the variations from theory are all in one direction. It is hardly possible at present to say whether this means anything, or is only ascribable to accident. One more example of regularity among atomic weights is worth noting, namely, the relation which connects the members of the oxygen group. Here we have oxygen, 16; sulphur, 32; selenium, 79.5; and tellurium, 128. These higher numbers are simple multiples of the lowest; there being only a variation of half a unit (minus) in the case of selenium. Since these elements are very similar in their chemical relations, this regularity is extremely significant. Can it be due to chance, and void of real meaning?

But all these relations *prove* nothing—they merely suggest. Standing by themselves they would signify comparatively little; but considered with other analogous evidence they help to found an almost overwhelming argument. The concurrent testimony supplied by the specific or atomic volumes of the elements is particularly strong.

The specific volume of any substance is the quotient obtained upon dividing its atomic weight by its specific gravity. This value may be supposed to represent the volume of an atom of the substance plus the sphere of unoccupied space immediately surrounding and belonging to it. Leaving theoretical definitions out of account, however, we shall find, upon comparing the specific volumes of solid and liquid substances, many extraordinary relations. Often, all the members of an elementary group have equal values. This is the case with the closely-related metals platinum, iridium, osmium, palladium, rhodium, and ruthenium. They have different atomic weights and different specific gravities; yet the quotient obtained upon dividing the former by the latter is the same in every instance. The same thing holds good of the group formed by iron, cobalt, nickel, chromium, manganese, copper, and perhaps also uranium. Here the regularity extends even beyond the elements themselves, for their corresponding compounds have, with few exceptions, equal specific volumes also. An altogether different, but on the whole more remarkable, relation is furnished by the alkaline metals lithium, sodium, potassium, and rubidium; whose specific volumes are respectively 11.9, 23.7, 45.1, and 56.2. These values are almost exactly multiples of the first, standing to it in the ratio of 1 : 2 : 4 : 5. The slight variations from accuracy in this case are very far within the limits of experimental error. Almost as remarkable multiple relations are found in several other series, and apply not only to the specific volumes of the solid elements, but to their values in liquid compounds also. Closely connected with this subject is that of crystalline form. As a general, though not invariable rule, elements having equal specific volumes are isomorphous; that is, crystallize alike; a fact which may be extended to a very large number of compound series as well.

It would be easy to go on to almost an indefinite extent multiplying examples of relationship between the elements. There is hardly any set of physical properties which may not be made to emphasize the idea that these substances are internally related. Take, for example, their specific heats, which, multiplied by their atomic weights, give a constant quantity in the neighborhood of 6.3. That is, according to the law of Dulong and Petit, all elementary atoms have equal capacities for heat. But space is limited, so that we must omit the consideration of many important facts, and pass to the theoretical discussion of those already cited. All this evidence suggests quite emphatically that the elements are not totally distinct and independent bodies. Are they, then, compounds formed from a few simple substances, or are they modifications of but one primal matter? Strong arguments may be adduced in favor of either view, although neither can be yet demonstrated.

The idea that a very few true elements, uniting together in a variety of proportions, may give rise to all the bodies which we now look upon as elementary, derives perhaps its strongest support from an analogy pointed out by Prof. Cooke something like twenty years ago. He first called attention to the many serial relations which connect the members of any elementary group, and then showed how much these groups resemble the homologous series of organic chemistry. In such a series we have a number of compounds each differing from its immediate predecessor in a very definite way. Thus, in the series of alcohol radicles, we have first the hydrocarbon methyl. Adding to this an atom of carbon and two of hydrogen, we get the second member of the series; the third is formed by the same addition to the second, the fourth similarly derived from the third, and so on. The difference between the molecular weights of any two successive members in this series is always the same. Just so in some groups of elements, as we have already seen. The atomic weight of lithium is seven, add sixteen and we get that of sodium, while another increase of sixteen gives the value of potassium. Again, the atomic weight of sulphur is that of oxygen plus sixteen; three times sixteen more brings us to selenium, and another forty-eight reaches the equivalent of tellurium. Here certain multiples of sixteen are missing; do they correspond to the atomic weights of undiscovered elements? Such a speculation is curious, but not very profitable.

The analogy, then, between the groups of elements and the homologous series of organic compounds is quite striking, although it may not be very precise. Hence Cooke suggested that, if the elements were compounds, their resemblances might be explained by supposing them to form series like the hydrocarbons, in which bodies of similar constitution are akin in general properties. Now, this conception was certainly very brilliant, and rendered intelligible many important facts which before it were unclassified. It did not, however, suggest the possible unity of matter, but merely put the ultimate question regarding the nature of the elements a step farther back. Instead of many, it gave us the idea of few elementary bodies; why and how these differed were yet to be found out. Prof. Cooke was, fortunately, too cautious a chemist to put forward views of this sort dogmatically; he did not offer a theory even; he only made suggestions to be taken later at their true value, whatever that might be.

The other side of the question, that of the unity of matter, has been worked up by several chemists in a variety of ways. Some have studied the phenomena of crystallization and drawn their conclusions therefrom; others have taken up the subject from a dynamical point of view. Given atoms of one kind only, how to arrange these in different aggregations so as to present all the phenomena offered by our supposed elements in their relations to the various modes of energy? Perhaps in the discussion of this problem Gustavus Hinrichs would stand first. His conclusions may be easily questioned, but the ability and ingenuity displayed in reaching them cannot be denied.

To the general reader, or to the beginner in chemistry, the difficulties confronting the unitary view of matter may seem to be very great. Doubtless they are; but then every side of the subject is beset with difficulties. Obstacles must be surmounted, and the worst are not in this direction. The mind unused to speculations of this sort will probably encounter its greatest embarrassment in trying to understand how one substance alone can assume such a diversity of forms. That such a thing is within the limits of possibility, may be illustrated by reference to the facts of allotropy and isomerism. Quite a number of our present elements are known to be capable of existing in a variety of dissimilar modifications. Carbon is found as charcoal, graphite, and diamond; phosphorus exists both in its white and in its red modifications; oxygen is allotropic as ozone. Similar examples are furnished by arsenic, selenium, and, very notably, by sulphur. Among compounds, especially in organic chemistry, many cases occur in which several different bodies have precisely the same elementary composition. For instance, the essential oils of rose, bergamot, orange, lemon, lavender, turpentine, rosemary, nutmegs, myrtle, peppermint, etc., unlike as they may be in outward properties, are all composed of carbon and hydrogen in exactly the same percentages. The same atoms occur, but differently arranged. Many other sets of isomeric bodies are known in which this diversity of atomic arrangement can be distinctly traced, and the reasons for difference clearly pointed out. The limitations of space prevent their description here.

Now, since a single element may exist in several different forms, and since the same atoms can unite together so as to produce compounds very unlike each other, the chief objection to the unitary view is removed. Why may not all the so-called elements be allotropic modifications of one, or else isomeric bodies formed by the union of two or three such modifications? Such a supposition is by no means absurd, although, to be sure, it is not capable of rigid demonstration. It is only a speculation, but then within it are some fair probabilities. These may be strengthened by an appeal to spectroscopic evidence, and to the prevalent hypothesis concerning the origin of our planet.

If we examine the spectra of our supposed elements, we shall notice no more striking fact than the extent to which they differ in complexity. Some bodies give spectra of only one or two lines, while others are represented by hundreds. This atom emits light of a single wave-length, that one gives out rays of nearly half a thousand different kinds. Now, what do these facts mean? Do they indicate structural differences within molecules such that each bright line in a spectrum corresponds to a true element? Such a notion, if true, would lead to an alarming multiplication of elementary bodies, increasing our present confusion to an indefinite extent. If every possible wave-length of light represented a special element, the number of elements would be infinite. Clearly, then, this speculation, although frequently suggested, has very little to recommend it, and need not be entertained. Still, the fact of varying complexity among the elementary spectra remains to be accounted for. It certainly suggests a corresponding difference of complexity among the elements themselves, but of what nature? This question can hardly be answered directly, although it admits of interesting discussion, for which, unfortunately, we have little space to spare. Suffice it to say that spectroscopic phenomena are quite in harmony with the idea that all matter is at bottom one, our supposed atoms being really various aggregations of the same fundamental unit. It is approximately true that the simpler spectra are furnished by the elements of low atomic weight, while the multitudes of lines come from the heavier atoms. There are prominent exceptions to this rule, still it affords some support to our central idea.

But the spectroscope makes its most emphatic suggestions in favor of the unity of matter when it is applied to the study of the heavenly bodies. This subject I discussed in THE POPULAR SCIENCE MONTHLY for January, 1873, and some months later Lockyer gave it prominence in England, his paper calling forth a good deal of comment. Therefore, only a brief *résumé* of my original suggestions is desirable now.

Everybody knows that the nebular hypothesis, as it is to-day, draws its strongest support from spectroscopic facts. There shine the nebulæ in the heavens, and the spectroscope tells us what they really are, namely, vast clouds of incandescent gas, mainly, if not entirely, hydrogen and nitrogen. If we attempt to trace the chain of evolution through which our planet is supposed to have grown, we shall find the sky is full of intermediate forms. The nebulæ themselves appear to be in various stages of development; the fixed stars or suns differ widely in chemical constitution and in temperature; our earth is most complex of all. There are no "missing links" such as the zoölogist longs to discover when he tries to explain the origin of species. First, we have a nebula containing little more than hydrogen; then a very hot star with calcium, magnesium, and one or two other metals added; next comes a cooler sun in which free hydrogen is missing, but whose chemical complexity is much increased; at last we reach the true planets with their multitudes of material forms. Could there well be a more straightforward story? Could the unity of creation receive a much more ringing emphasis? We see the evolution of planets from nebulæ still going on, and parallel with it an evolution of higher from lower kinds of matter.

Just here, perhaps, is the key to the whole subject. If the elements are all in essence one, how could their many forms originate save by a process of evolution upward? How could their numerous relations with each other, and their regular serial arrangements into groups, be better explained? In this, as in other problems, the hypothesis of evolution is the simplest, most natural, and best in accordance with facts. Toward it all the lines of argument presented in this article converge. Atomic weights, specific volumes, and spectra, all unite in telling the same story, that our many elements have been derived from simpler stock.

I know that all this is only speculation, but surely it is not baseless. Science is constantly reaching forward from the known to the unknown, partly by careful experiment, and partly by the prophetic vision of thought. It first discovers facts, and then seeks to interpret them, although oftentimes the interpretation is not capable of absolute proof. So with the material of this article. We have seen that many relations connect in some mysterious way those bodies which we commonly regard as simple, and we have sought to determine their meaning. What can they mean, save that the elements are not elementary? How could the elements have originated but by a process of evolution?

THE NATURE OF FLUORESCENCE.[1]

By Dr. EUGENE LOMMEL,
PROFESSOR OF PHYSICS IN THE UNIVERSITY OF ERLANGEN.

THE question now arises, What becomes of the rays that have undergone absorption? Are they in fact, as they appear to be, annihilated? A series of phenomena now to be considered will give us an answer to these questions.

If water containing a little *esculine*, a substance contained in the bark of the horse-chestnut in solution, be placed in a flask, and the rays of the sun or of the electric lamp, concentrated by a lens situated at about its focal distance from the vesel (Fig. 1), be directed upon it, the cone of light thrown by the lens into the interior of the fluid will be seen to shine with a lovely sky-blue tint. The particles of the solution of esculine in the path of the beam become spontaneously luminous, and emit a soft blue light in all directions. The cone of light appears brightest at the point where it enters into the fluid through the glass, and quickly diminishes in brilliancy as it penetrates more deeply.

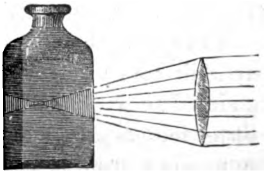

Fig. 1.—Illustration of Fluorescence.

There are great numbers of fluid and solid bodies which become similarly self-luminous under the influence of light. This peculiarity was first observed in a kind of spar occurring at Alston Moor, in England, which, itself of a clear green color, appears by transmitted solar light of a very beautiful indigo-violet color. From its occurrence in calcium fluoride the phenomenon has been named *fluorescence.*

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[1] From "The Nature of Light," No. XIX. of the "International Scientific Series."

In order to understand more precisely the circumstances under which fluorescence occurs, the solution of esculine must again be referred to. The light, *before* it reaches the lens, must be allowed to pass through just such another solution of esculine contained in a glass cell with parallel walls. The cone of light proceeding from the lens, as long as it passes through the air, does not appear to have undergone any material change, it is just as bright and just as white as before. In the interior of the fluid, however, it *no longer presents a blue shimmer, but becomes scarcely perceptible.*

Thus it is seen that light which has traversed a solution of esculine is no longer capable of exciting fluorescence in another solution of esculine. Those rays consequently which possess this property must be arrested by the first solution of esculine. Similar results are obtained in the case of every other fluorescent substance.

The general proposition can therefore be laid down, *that a body capable of exhibiting fluorescence fluoresces by virtue of those rays which it absorbs.*

In order to determine what rays in particular cause the fluorescence of esculine, the spectrum must be projected in the usual way; but, instead of its being received upon a paper screen, it must be allowed to fall upon the wall of a glass cell containing a solution of esculine, that is to say, upon the solution itself, and it must then be observed in what parts of the spectrum the blue shimmer appears. The red and all the other colors consecutively down to indigo appear to be absolutely without effect. The bluish shimmer first commences in the neighborhood of the line *G* (Fig. 2), and covers not only the violet part of the spectrum, but *stretches far beyond the group of lines H* to a distance which is about equal to the length of the spectrum visible under ordinary circumstances.

From this the conclusion must be drawn that there are rays which are still more refrangible than the violet, but which in the ordinary mode of projecting the spectrum are invisible; these are termed the *ultra-violet rays.* They become apparent in the esculine solution because they are capable of exciting the bluish fluorescent shimmer in it. If sunlight have been used in the above experiments, the well-known Fraunhofer's lines appear upon the bluish ground of the fluorescing spectrum, not only from *G* to *H*, but the ultra-violet part also appears filled with numerous lines, the most conspicuous of which are indicated by the several letters *L* to *S* (Fig. 2). That these lines, like the ordinary Fraunhofer's lines, belong properly to solar light, and do not depend upon any action of the fluorescing substance, is evident from the circumstance that with the electric light they are no more apparent in the ultra-violet than in the other colors, and further, because the same lines are seen in the solar spectrum, whatever may be the fluorescing substance under examination.

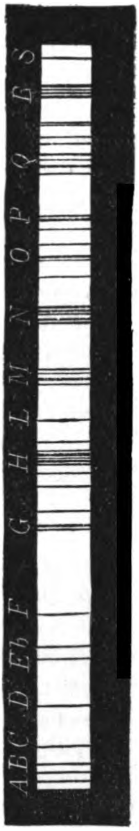

Fig. 2.—Solar Spectrum with the Ultra-violet Portion

Quartz has the power of transmitting the ultra-violet rays far more completely than glass. If, therefore, the glass lens and prism hitherto used for projecting the spectrum be replaced by a quartz lens and prism, the ultra-violet part of the spectrum is rendered much brighter and is extended still farther than before.

The ultra-violet rays of the spectrum can, moreover, be seen, without the intervention of any fluorescing substance, through a glass, or, still better, through a quartz prism, if the bright part of the spectrum between *B* and *H* (Fig. 2) be carefully shut off. With feeble illumination its color appears indigo-blue, but with light of greater intensity it is of a bluish-gray tint (lavender). The ultra-violet rays thus ordinarily escape observation, because they produce a much feebler impression on the human eye than the less refrangible rays between *B* and *H*.

An explanation is thus afforded why the solution of esculine, apart from its absorption, is colorless when seen by transmitted light; for, since it absorbs only the feebly luminous violet and the entirely imperceptible ultra-violet rays, the mixed light that has passed through it still appears white, and is not rendered materially fainter.

If the solar spectrum be thrown in the above-mentioned manner upon the fluid, its fluorescing part everywhere exhibits the same bluish shimmer; and spectroscopic examination shows that this bluish light has always the same composition, whether it is excited by the *G* rays, or by the *H* rays, or by the ultra-violet rays, and that it is formed of a mixture of red, orange, yellow, green, and blue. It is thus seen that the different kinds of homogeneous light, as far as they are generally effective, produce *compound* fluorescent light of identical composition, the constituents of which, nevertheless, are collectively *less refrangible than, or are at most equally refrangible with*, the exciting rays.

Among other fluorescing bodies may be mentioned the solution of quinine, which is as clear as water, and has a bright-blue fluorescence; the slightly yellow petroleum, with blue fluorescence; the yellow solution of turmeric, with green; and the bright-yellow glass containing uranium, which fluoresces with beautiful bright-green fluorescence. It admits of easy demonstration that in these bodies also it is the more refrangible rays that call forth fluorescence. For, if we illuminate them with light which has passed through a red glass, no trace of fluorescence is visible. But, if the red be exchanged for a blue glass, the fluorescence becomes as strongly marked as with the direct solar light. A remarkable phenomenon is presented in the splendid bright-green light which is emitted by uranium glass under the action of blue illumination.

The highly-refrangible rays which possess in so high a degree the power of exciting fluorescence are contained in large proportion in the light emitted by a Geissler's tube filled with rarefied nitrogen. In order to expose fluorescing fluids to the influence of this light, the arrangement represented in Fig. 3 may be employed with advantage. A narrow tube is surrounded by a wider glass tube, into which the fluid is introduced by a side opening which can be closed if required. Another form of Geissler's tube is represented in Fig. 4, which contains in its interior a number of hollow spheres composed of uranium glass. Where a beam of reddish violet nitrogen light traverses the tube, the uranium glass balls shine with a beautiful bright-green fluorescent light.

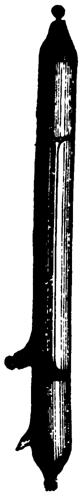

FIG. 3.—GEISSLER'S FLUORESCENCE TUBE.

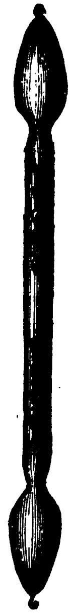

FIG. 4.—GEISSLER'S TUBE WITH URANIUM GLASS SPHERES.

The electric light passing between carbon-points is rich in rays of high refrangibility, indeed the ultra-violet end of its spectrum reaches even farther than that of the solar spectrum. In the light of the magnesium-lamp the ultra-violet rays are also abundant, and both sources of light are therefore particularly well adapted to produce fluorescence, while gas and candle light are nearly inoperative on account of the small amount of the more refrangible rays they contain.

It would nevertheless be incorrect to infer from the above facts that the more refrangible rays are exclusively capable of exciting fluorescence. A red fluid which is an alcoholic solution of naphthaline red, and which in ordinary daylight fluoresces with orange-yellow tints of unusual brilliancy, will serve to demonstrate that even the less refrangible rays are capable of producing this effect. In fact, if the spectrum be projected upon the glass cell containing the fluid (Fig. 5), the yellow fluorescent light will be seen to commence at a point intermediate to *C* and *D*, and therefore still in the red, and to extend over the whole remaining spectrum as far as the ultra-violet. The strongest fluorescence by far is shown behind the line *D* in the greenish-yellow rays. It then again diminishes, and becomes a second time more marked between *E* and *b*; thence onward the fluorescence becomes fainter, then increases again in the violet, and gradually vanishes in the ultra-violet. In naphthaline red, therefore, there are rays of low refrangibility, namely, the green-yellow rays behind *D*, by which its fluorescence is most powerfully excited.

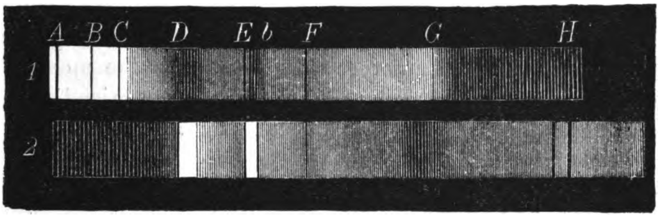

Fig. 5.—Absorption and Fluorescing Spectrum of Naphthaline Red.

The fluorescence spectrum received upon the fluid shows, as we have already mentioned, three regions of stronger fluorescence, and the absorption spectrum of naphthaline, which, by placing a small cell filled with the solution in front of the slit, may be obtained upon a paper screen, gives a key to the cause of this phenomenon. In this spectrum Fig. 5 (1), a completely black band is visible in the green-yellow behind *D*, a dark band between *E* and *b*, while the violet end appears shaded. On employing a very strong solution of the naphthaline coloring material, the whole spectrum vanishes with the exception of the red end, which remains apparent to a point behind *C*. If now the absorption spectrum be compared with that thrown upon the fluid, the intimate relation between absorption and fluorescence that has already been pointed out in the esculine solution is corroborated in the minutest particulars. *For every dark band in the absorption spectrum corresponds to a bright band in the fluorescing spectrum.* Every ray absorbed by the fluid occasions fluorescence, and the fluorescent light produced is the brighter, the more completely the ray is absorbed.

A second example of the excitation of fluorescence by rays of small refrangibility is exhibited by a solution of chlorophyll. The spectrum projected upon this green fluid fluoresces of a dark-red color, from *B* to a point within the ultra-violet, exhibiting at the same time bright bands which correspond with the dark bands in the absorption spectrum. Between *B* and *C*, where the greatest amount of absorption occurs, the fluorescence is also the most marked. But it is the middle red rays which here act so powerfully as excitants. It is remarkable that the red fluorescent light which the chlorophyll solution emits likewise lies, in regard to its refrangibility, between *B* and *C*. Chlorophyll solution affords a proof that all rays of the spectrum, with the exception of the extreme red in front of *B*, are capable of calling forth fluorescence. Their capacity for doing so depends simply on the power of absorption of the fluorescing substance. The most refrangible violet and ultra-violet rays are, however, characterized by the circumstance that they are capable of exciting all known fluorescing bodies.

Fluorescent light is only perceived so long as the fluorescent substance is illuminated by the exciting rays. As soon as the light falling on it is obstructed, the colored shimmer vanishes. It is only in the case of some fluorescing solid substances, as, for example, fluor-spar and uranium glass, that, with the aid of appropriate apparatus (Becquerel's phosphoriscope), a very short continuance of the fluorescence may be observed to take place in the dark.

There are, however, a number of bodies which, after being excited to self-luminosity by a brilliant light, continue to shine for a certain time in the dark. A series of pulverulent white substances, namely, the sulphur compounds of calcium, strontium, and barium (which should be kept in hermetically-sealed glass tubes), do not exhibit the faintest light in a dark room. Moreover, if they be covered with a yellow glass and illuminated with the light of a magnesium-lamp, they remain as dark as before. But if the yellow be exchanged for the blue glass, and the magnesium-light be allowed to play upon them for a few seconds only, they emit in the dark a soft light, each powder having its own proper tint of color. This power of shining in the dark *after having been exposed to the light is called phosphorescence.* The property is possessed in a high degree not only by the above-named artificially-prepared substances, but by various minerals, as the diamond, fluor-spar, and a variety of fluor-spar called chlorophane.

THE CONTROVERSY ON ACOUSTICAL RESEARCH.

TYNDALL ON SOUND.[1]

THE work of Prof. Tyndall on the philosophy of sound has won for itself, in its former editions, the highest possible recognition among scientific men, not only in England, but in other countries. A little more than a year ago, the second edition of this book was translated into German under the special supervision of such eminent investigators as Helmholtz and Wiedemann. In the work before us we have the third revision of the eminent professor's observations under this head. In preparing it, he says, he has subjected the previous edition to a careful reëxamination, and, in so doing, has "amended as far as possible its defects of style and matter, and paid at the same time respectful attention to the criticisms and suggestions which the former editions called forth."

In the preface to this publication it is announced by Prof. Tyndall that the new matter of greatest importance which has been introduced into it is an account of an investigation which during the past two years he has been conducting in connection with the Elder Brethren of the Trinity House. It may not be known to all our readers that what we call our Lighthouse Board at Washington is known in England as "The Trinity House." The title carries us back to the era when monasticism was prevalent in Europe. In its original charter, the body was named "The Masters, Wardens, and Assistants of the Guild, Fraternity, or Brotherhood of the most Glorious and Undivided Trinity, and of St. Clement, in the Parish of Deptford Stroud, in the County of Kent." In the year 1836, an act of Parliament vested in this "Trinity House," as then constituted, the entire control of the lighthouses of England and Wales, and gave it certain powers over the lights in Scotland and Ireland. Prof. Tyndall appears to have entered on his duties as "the scientific adviser" of the Elder Brethren shortly after his return to England at the close of his lecturing tour in the United States in the year 1873. In the seventh chapter of the present volume, under the head of "Researches on the Acoustic Transparency of the Atmosphere in Relation to the Question of Fog-Signaling," he gives the processes and the results of some very interesting observations which he has conducted under the patronage of the British Trinity House. The general results of these observations had already transpired, but in the work before us they have received the professor's definite statement side by side with a narrative of the researches from which they have been deduced. It is to this portion of the volume, containing "the new matter of greatest importance," that we propose to confine our attention in this short review.

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[1] From the *Nation* of October 28, 1875.

The reader who turns to this seventh chapter will find that it opens with an "introduction" professing to give "a summary of existing knowledge" in the matter of fog-signaling. The writer states that while the *velocity* of sound has formed the subject of repeated and refined experiments by the ablest philosophers, "the publication of Dr. Derham's celebrated paper in the 'Philosophical Transactions' for 1708 *marks the latest systematic inquiry into the causes which affect the intensity of sound in the atmosphere.*" And, after making this statement, the professor immediately adds as follows: "Jointly with the Elder Brethren of the Trinity House, and as their scientific adviser, I have recently had the honor of conducting an inquiry designed to fill *the blank here indicated.*" In order still further to impress on the reader a sense of the magnitude of this "blank," Dr. Tyndall indulges in one or two preliminary references which, he says, "will suffice to show the state of the question when this [his] investigation began." The first of these references cites the opinion of Sir John Herschel to the effect that fogs and falling rain, and more especially snow, had been found by Derham "to tend powerfully to obstruct the propagation of sound." The second of his references is made to what he calls "a very clear and able letter" addressed by Dr. Robinson, of Armagh, to the British Board of Trade in 1863. In this "very clear and able letter" Dr. Robinson states that sound is the only known means for coping with fogs, but about it, he adds, "the testimonies are conflicting, *and there is scarcely one fact relating to its use as a signal which can be considered as established.*" But Dr. Robinson is clear on one point—to wit, that "fog is a powerful damper of sound."

On the strength of these historical references, Dr. Tyndall ventures the remark that, prior to the investigation conducted by him, the views enunciated under this head by Derham, Herschel, and Robinson, "were those universally entertained." It was in order to fill "the blank" indicated by the universal prevalence of such erroneous opinions that *his* inquiry, he says, was set on foot. And his inquiry, he tells us, was begun May 19, 1873.

Now, it is a matter, not only of scientific knowledge, but of public notoriety in this country, that extensive researches on "the causes which affect the intensity of sound in the atmosphere" had been made by the United States Lighthouse Board long before Prof. Tyndall began his investigations. That he should have chosen to ignore the fact in the body of his present volume becomes only the more surprising when, on turning to its preface, we find that he was, as he confesses, "quite aware *in a general way* that labors, like those now for the first time made public, had been conducted in the United States," and "this knowledge," he subjoins, "was not without influence upon my conduct." If his knowledge of the similar labors conducted under this head in the United States was not, as he acknowledges, without influence on his conduct in giving direction to his researches, it will naturally occur to ordinary minds that this knowledge should also have been "not without influence" on his pen when he was professing to give a summary of the existing state of science on this subject. And when to this statement of the case, as acknowledged by himself, we add that he was made acquainted with the nature and purport of Prof. Henry's explorations on this question, not only "in a general way," but also in a very special way, it becomes still more inexplicable that, in defining "the blank" which he claims to have filled by his recent inquiry, he should have disregarded the labors and results of American science, and that, too, while profiting by the instruments and methods of that science in the very conduct of his investigations. The reader will understand the force of our remark that Prof. Tyndall was acquainted with the researches of Prof. Henry, not only "in a general way," but also in a special way, when we state that a paper by the latter—on the abnormal phenomena of sound in relation to fog-signaling—was read by its author in the hearing of Prof. Tyndall at a meeting of the Washington Philosophical Society, called for the purpose of doing honor to the British *savant* while he was sojourning in the national capital. And the force of our remark that he has ignored the results of American science in magnifying "the blank" which he describes, while profiting by the instruments and methods of that science in conducting his inquiry, will be understood when we say that the researches of Prof. Tyndall were prosecuted with the help of a steam-siren, gratuitously lent to him by the Lighthouse Board at Washington, constructed and patented by a citizen of New York, and introduced by Prof. Henry into the lighthouse system of the United States.

We are now prepared for the next stage of this review. It so happened that while Prof. Tyndall was conducting his researches on sound in relation to fog-signaling, an officer of the United States Corps of Engineers, Major Elliot, had been deputed by the Lighthouse Board at Washington to make a tour of inspection in Europe, with instructions to report upon matters relative to lighthouse apparatus and the management of lighthouse systems. Major Elliot reached London a few days before Prof. Tyndall began his experiments at Dover, and was courteously invited to be present, but for want of time was compelled to forego the privilege. The results of the English experiments were, however, subsequently communicated to Major Elliot by Sir Frederick Arrow, the Deputy Master of Trinity House (who, we are sorry to say, has since deceased), and were embodied in his report on the "European Lighthouse Systems," as recently published. The publication of Major Elliot's report was accompanied, in the annual report of the United States Lighthouse Board for the year 1874, with the following observations:

"Major Elliot gives a detailed account of a late series of experiments by the

Trinity House Board on fog-signals. Now, although this account is interesting in itself to the public generally, yet, being addressed to the Lighthouse Board of the United States, it would tend to convey the idea that the facts which it states were new to the board, and that the latter had obtained no results of a similar kind; while a reference to the Appendix to this report *will show that the researches of our Lighthouse Board have been much more extensive on this subject than those of the Trinity House, and that the latter has established no facts of practical importance which had not previously been observed and used by the former.*"

The "Appendix" here referred to is from the pen of Prof. Henry, the chairman of the board, and details elaborate experiments on sound in relation to fog-signaling, as pursued in the service of the United States Lighthouse Board since the year 1855. Brought to book by this "Appendix," Prof. Tyndall asks his readers, in the preface of the present edition of his volume, to bear in mind that "the Washington Appendix was published nearly a year after his [my] report to the Trinity House." But in so writing it seems to have escaped his notice that in a subsequent part of this same preface he has confessed that he was "quite aware in a general way" that labors like his own had been conducted in the United States, and that "*this knowledge was not without influence on his conduct.*" And in so writing he forgets, too, that he was an interested listener to the paper read by Prof. Henry on this subject in his hearing while he was in the United States, and before he had turned any attention at all to the phenomena of sound in connection with fog-signals. He states in the body of his book, as already mentioned, that his inquiry under this head began on May 19, 1873, several months after his "general" and his special knowledge of what had been accomplished in this country. And yet, in the face of all these facts and acknowledgments he has allowed his "summary of existing knowledge" on the subject to stand without any recognition of American science in the premises—a suppression which does as little credit to his scientific generosity as to his literary art, for he can be convicted of delinquency in respect of the former by the inconsistency of statement into which he has fallen through a want of dexterity in the latter.

We may, therefore, safely leave the acknowledged record to substantiate the claims of the United States Lighthouse Board when they represent that their researches, running through many years, "are much more extensive on this subject than those of the Trinity House." It remains for us only to consider the second branch of their representation—namely, that the latter (the Trinity House) "has established no facts of *practical importance* which had not been previously observed and used by the former (the United States Lighthouse Board)." In support of this statement we may point to the fact that Prof. Tyndall nowhere pretends to have established by his researches any improvements whatsoever on the methods or instruments of fog-signaling as practised in the United States. On the contrary, he acknowledges that in the choice of fog-signals for British use his "strongest recommendation applies to an instrument for which we are indebted to the United States." He will remember, moreover, that while he was sojourning in the United States he sought and obtained opportunities from Prof. Henry to observe the operation of the steam-siren in the lighthouse at Sandy Hook. At that time, if not before, he was made acquainted with the progress not only of American science but also of American art under this head. And in view of the fact that, as the "scientific adviser" of the Elder Brethren of the Trinity House, he has counseled them to discard their English horns and whistles and to substitute for them the steam-sirens which have been, for several years, in the use of our American lighthouses, it would seem that the second branch of the claim advanced by the board at Washington stands in as little need as the first of any additional reënforcement at our hands. Bacon rejoiced in the fact that his philosophy was a philosophy which brought forth fruit in the service of man. The progress of American science in this department has been constantly bearing fresh fruit in the interests of commerce and for the relief of the mariner. Daboll's trumpet, an American invention, came to supersede the use of gongs, and bells, and horns, and guns. To-day the steam-siren, an instrument devised and perfected under the direction of the United States Lighthouse Board, is acknowledged to be without a rival as an efficient fog-signal.

It is no part of our present purpose to institute a critical inquiry into the conflicting views of Prof. Henry and of Prof. Tyndall with regard to the hypotheses respectively espoused by each for the explanation of the phenomena of sound in its passage through wide tracts of air. Prof. Henry believes that the direction and the rate of wind-currents are important elements in the problems presented by the phenomena in question. Prof. Tyndall admits that "the well-known effect of the wind is exceedingly difficult to explain," but he insists on making up the fagot of his scientific opinions on the subject at once and forever without taking the "viewless winds" into his account. He finds a sufficient explanation of all the abnormal phenomena in the assumption of ideal clouds of vapor mingling with the atmosphere so as to disturb its homogeneity, and thereby to quench the body of sound. There is nothing in the working hypothesis of Prof. Henry which excludes any truth there may be in the working hypothesis of Prof. Tyndall. But, in the present provisional state of his inquiries on the subject, the former is disposed to question the sufficiency of the explanation adduced by the latter as an efficient cause of all the phenomena in question. With the modesty and reserve of the true physical philosopher, in the present unfinished state of scientific inquiry, Prof. Henry waits for the wider knowledge which shall furnish the basis of an assured induction meeting all the requirements of the problem.

Prof. Tyndall, however, is impatient of any contradiction. He admits that he has not verified the effect of wind-currents "by means of a captive balloon rising high enough to catch the deflected wave," but none the less he ventures to propound his hypothesis as the last word of science in the premises. Indeed, he takes great credit to himself for having been able to rise above "the authority" of Prof. Henry in this investigation. He says that in one of his "phases of thought" on the question he passed through the solution "which Prof. Henry now offers for acceptation," "weighed it in the balance," and "found it wanting." And, as if this language were not supercilious enough, he proceeds to indulge in the following self-complacent reflections:

> "But though it [Prof. Henry's solution of ocean-echoes] thus deflected me from the proper track, shall I say that *authority in science is injurious?* Not without some qualification. It is not only injurious, but deadly, when it cows the intellect into fear of questioning it. But the authority which so merits our respect as to compel us to test *and overthrow all its supports*, before accepting a conclusion opposed to it, is not wholly noxious. On the contrary, the disciplines it imposes may be in the highest degree salutary, though they may end, *as in the present case, in the ruin of authority.*"

It is impossible to conceive of language more expressive of vanity, conceit, and arrogance, than this ascription of intellectual superiority to which Prof. Tyndall treats himself on the assumption that he has laid "the authority" of Prof. Henry in "ruins" upon the question of atmospheric sound. At no time and in no place has Prof. Henry assumed to speak "by authority" on the subject. The man of straw whom Tyndall sets up under cover of Henry's name, in order to exhibit upon it the strength and prowess of his intellectual muscle, is a cheap device of rhetoric which a much inferior man might have disdained to employ in a case like this. The cause of science does not profit by the self-laudation of its votaries, and Prof. Tyndall's praises are in the mouths of too many people to render it necessary for him to praise himself at the expense of Prof. Henry or of anybody else.

REPLY OF PROFESSOR TYNDALL.[1]

To the Editor of the Nation.

SIR: I have been favored with a copy of the *Nation* of October 8th, and would ask permission to make a few remarks on the *critique* of my work on "Sound" therein contained.

With regard to Prof. Henry, I hope I am not presumptuous in venturing the opinion, and expressing the belief, that his earlier scientific labors were marked by rare power and originality, and that his later years have been usefully and honorably employed in the service of his country. Such, if I dare say so, are the sentiments which I have ever expressed regarding Prof. Henry here and elsewhere.

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[1] From the *Nation* of December 23, 1875.

When I first learned that he was in danger of falling into what I considered to be grave scientific error, I went as far as friendliness dared go to avert it. I addressed to him a private letter, in which I tried to impress upon him the completeness and conclusiveness of the evidence which he seemed disposed to call in question. He did not honor that letter with any notice, preferring to discuss the subject publicly in the "Report of the Washington Lighthouse Board." He was clearly within his right in doing so; but I submit that I only exercised my right when I met him on ground thus chosen by himself.

No English gentleman that I have consulted can discern in what I have written any violation of the dignity of scientific debate; but your article would lead to the inference that I had both violated common honesty and taken leave of common-sense. I will not quote your words, because I cherish the hope that when you have reflected on them you will regret them. When I say "you," I mean the editor of the *Nation*, whose acquaintance I had the honor to make, and whose kindness I had the privilege to experience, in New York—I do *not* mean the writer of the article. Let me respectfully assure you, then, that, when I spoke of being "deflected by authority," "Prof. Henry's solution of ocean-echoes" was not at all in my mind, nor his "ruin," partial or total, in my calculations. Consider, I pray you, how impossible it is that this could have been the case. The "deflection" spoken of is expressly described as occurring at the outset of an investigation begun in May, 1873, *whereas the Washington report containing Prof. Henry's solution of ocean-echoes is the report for* 1874, *which did not reach Europe until the spring of* 1875. This, then, is the crumbling foundation on which your critic builds his odious charge. In verity, the remark on which he pours his peroratory invective was not meant for "laudation" of any kind, but merely to show the "polar" character of authority—its good side and its bad.

It is easy, as you know, Mr. Editor, to sneer and to assail; but less easy to show, without going into details not worth the labor, that the sneer is unmeaning, and the assault unfair. Nevertheless, the broad lines on which, in the present instance, I would meet my anonymous assailant may, I think, be made clear. He industriously mixes together things which ought to be kept apart—experiments on fog-signals and inquiries into "the causes which affect the transmission of sound through the atmosphere." The "blank" which I proposed to fill is stated, with unmistakable clearness, to have reference solely to such "causes." Neither Herschel nor Robinson, as far as I know, ever made an experiment on fog-signals; still I quote them. Why? Because they are the most eminent and authoritative exponents of the theories of acoustic opacity which up to last year were entertained by the highest scientific minds. Theirs, moreover, and Arago's (not Prof. Henry's), was the "authority" which "deflected" me at first. Apart from the wind, the "causes" of acoustic opacity indorsed by these eminent men were rain, hail, snow, haze, and fog—everything, in short, that affected the optical clearness of the atmosphere. Prior to the South Foreland investigation, where, I would ask, is a "systematic inquiry" into these causes to be found? Surely, if such an inquiry has been published, it can be courteously pointed out and calmly discussed. If you can prove its existence you will have the right to demand from me the very fullest apology and reparation for stating that "no such systematic inquiry had to my knowledge been made." Even then I could not charge myself with untruth; for my "knowledge" was, and is, arithmetically what I have affirmed it to be; but I can confess ignorance and express regret.

Give me your patience while I endeavor still further to make this matter clear. As regards the invention of instruments and their practical establishment as fog-signals, so far was my knowledge behind "the science of the United States," that I had never seen or heard one of those great steam-whistles until I met them at the South Foreland. The common "siren" is well known to have been a familiar instrument with me, but the fog-signal I first saw and heard upon its native soil in America—not, however, as your critic puts it, but at the request, twice repeated, of Prof. Henry. Further, to the best of my recollection, prior to the month of May, 1873, I had only heard one or two experimental blasts from a fog-trumpet. In such work, then, I had neither part nor lot; and, if you will permit me to say so, though it is of the utmost practical value, I should hardly label such work with the name of "science." Quite apart from those practical achievements lies the inquiry into "the causes which affect the transmission of sound through the atmosphere." And, if I except the sagacious remark of General Duane which has been so curtly brushed aside, not a scintilla of light has been cast upon these causes by any researches ever published by the Lighthouse Board of Washington.

Will you allow me to say, in passing, that Major Elliot, the able and conscientious officer whose excellent "Report on the Lighthouses of Europe" was so displeasing to the board, *did* accept the invitation to Dover, and that to the present hour I feel indebted to him for the information and advice given to me at the time?

Upon my "conduct" and the knowledge which "influenced" it, your critic rings the changes of his wit. It is, after all, a very simple and straightforward matter. The "conduct" consisted in my emphatic advice to the Elder Brethren of the Trinity House not to confine themselves to home-made apparatus, but to include American ones in their inquiry. The subsequent trial led to the abandonment of the English instruments, and the adoption of others from Canada and the United States. The *siren*, for example—which your critic erroneous-ly says was lent "gratuitously" to *me*[1]—was paid for in February, 1874, and two others are at this moment on their way from New York to England. Both by word and deed have we acknowledged our real obligations to the United States; but what we did not and could not acknowledge (for it was non-existent) was, any solution of the conflicting and anomalous results obtained with these fog-signals—results so conflicting and so anomalous as to cause reflecting minds to entertain doubts as to the capacity of the observers. Apart from the friendship shown to me at the time, all that I remember of the meeting at Washington, to which your critic refers, is the utter perplexity of everybody present, myself included, in regard to the matter in hand. I had my guess—others had theirs; but we were quite at sea in our guesses, without a signal to guide us through the intellectual fog.

Knowing, indeed, the difficulty of the subject, when its investigation was first proposed to me by the Elder Brethren, I shrank (as Faraday had done before me) from a work of such obvious labor and such uncertain scientific promise. Doggedly, however, we attacked it, determined to go through the mechanical processes already followed by others, even if they led, as regards science, to an equally barren result. Out of the darkness at length came the dawn. We prolonged our investigations until they embraced every agent, save one, to which influence had been previously ascribed. The exception was snow. This, however, was directly met by observations made upon the *Mer de Glace* in the bitter winter of 1859, and which have been entirely confirmed by the later observations of General Duane. Having negatived antecedent theories, we wrought our way positively to the basis of the whole question. This we found in a cloud-world, invisible to the eye of sense, but as visible and certain to the mental eye as the ordinary cloud-world of our atmosphere. The lights and shadows of these "acoustic clouds"—the action of which must, at one time or another, have been noticed by every peasant within range of a peal of bells—sufficed to account for the most astounding variations of intensity. This, I say, has been established, not only by patient and long-continued observations afloat, but by laboratory experiments as indubitable as any within the range of physical science.

And, let me add, it was neither whistles nor trumpets, nor yet the siren, which pointed out the way to this solution, but experiments with *guns* ably served by artillerymen from Dover Castle.

I will not make any further draft upon your generosity, though, were it worth while to do so, other fallacies of fact and logic in your critic's article might be exposed. He says, or intimates, for example, that I became "adviser" to the Trinity House after my "lecturing tour in the United States in 1873." I relieved Michael Faraday of this duty in May, 1866. My friends in New York have already had to disperse other delusions regarding the "profits" of that "tour." Such statements are credible to the mean, incredible to the high-minded, and were therefore never thought worthy of refutation by me. And why should I now waste a word upon your critic's closing sentences? It will not make him noble to be told that envy is ignoble; that, if ever "praise" has been adjudged to me by his countrymen, it is not because I went out of my way to seek it. It came to me unasked—an incident, not an aim—shining, as your own Emerson would put it, pleasantly because spontaneously, upon the necessary journey of my life. It was not, I can truly say, the applause of large assemblies that constituted my chief happiness in the United States, but the ever-growing proof, for the most part undemonstrative, that, without swerving from my duty, I had gained a modicum of the affection of the American people. *That* I prized, and *that* I have sought to keep free from fleck, material or intellectual. For reasons best known to himself, your critic does not relish this relation; and he will damage it if he can. I cherish the belief that he will be unsuccessful. I have the honor to be, your obedient servant,

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[1] It was lent to the Trinity House Corporation; and I expressly signalize the lending as "an act of international courtesy worthy of imitation."

John Tyndall.

London, *November* 23, 1875.

SKETCH OF THOMAS STERRY HUNT, LL. D., F. R. S.

THE subject of the present notice, of whom an excellent portrait appears in this number, although still in middle life, has made extensive contributions to American science during the past generation, and has permanently identified his name with its progress and development. Choosing two of the most rapidly-advancing sciences, chemistry and geology, as his field of work, and studying them especially in their intimate and extensive interactions, he has had a large and honorable share in giving form to our present knowledge upon these subjects. Although an indefatigable experimenter and an extensive observer, Dr. Hunt is also eminently an original and philosophic thinker, and has taken an influential part in the establishment of the most matured scientific theories. He was early in the field of chemical speculation, and aided essentially in that revolution of views which has ended in the establishment of the "new chemistry."

Thomas Sterry Hunt was born on the 5th of September, 1826, in Norwich, Connecticut, where he received his early education. He began the study of medicine, but soon abandoned it for chemistry and mineralogy, and in 1845 became a private student with the present Prof. Benjamin Silliman at New Haven, acting meanwhile as chemical assistant to Prof. B. Silliman, senior, in the chemical laboratory of

Yale College. In 1847, while preparing to continue his studies in Great Britain, he was chosen to be chemist and mineralogist to the Geological Survey of Canada, then recently established under the direction of Sir William Logan, and having its headquarters at Montreal. This position he held for twenty-five years, resigning it in 1872. He was, during this time, for several years a professor in the Laval University at Quebec, where he lectured on chemistry and geology in the French language, and was afterward Professor of Chemistry and Mineralogy at McGill University, Montreal. Coming to Boston in 1872 he took the chair of Geology in the Massachusetts Institute of Technology, made vacant by the resignation of Prof. William B. Rogers, a post which he still occupies. He has never married.

His earlier scientific labors were chiefly in the domain of chemistry. Prof. B. Silliman, in his "History of American Contributions to Chemistry," which appeared in the "Proceedings of the Centennial of Chemistry" (*American Chemist* for 1874), says:

> "The name of no American chemist occurs more frequently, or in a more important relation to the progress and development of our science during the past quarter of a century, than that of Dr. Hunt. His contributions have been equally valuable in theoretical chemistry, in chemical philosophy, and in geological and mineralogical chemistry. No other author has covered a wider range than he. Not less than one hundred and thirty entries are found under his name in the second and third series of the *American Journal of Science*, and adding those published in Canada, England, and France, and some memoirs in the proceedings of various American societies, the total roll of his papers amounts to about one hundred and sixty titles."

A considerable proportion of these, however, relate to pure geology.

From the "History" just quoted, and from a biographical notice in THE AMERICAN CYCLOPÆDIA, we learn of Dr. Hunt's important contributions to theoretical chemistry, and his attempts to introduec into the sciences of chemistry and mineralogy a new philosophy, some points of which will be found in his address in 1874, at the Centennial of Chemistry at Northumberland, Pennsylvania, entitled "A Century's Progress in Chemical Theory." His papers on these subjects were widely copied and translated, and have greatly influenced modern chemistry. At an early date Dr. Hunt prepared a summary of organic chemistry, which he first defined to be the chemistry of carbon and its compounds, and which forms a part of Silliman's "First Principles of Chemistry" (1872). A statement of some of the aspects of the science will be found in the last annual address before the Massachusetts College of Pharmacy, delivered by him, on "The Relations of Chemistry to Pharmacy and Therapeutics" (Boston, 1875); and we present an abstract of this in the present number. It is said of Dr. Hunt, in the notice above referred to, that his researches on the chemistry of soda and mineral waters have probably been more extended than those of any other living chemist. These have been both synthetic and analytic, and we owe to him elaborate studies of the chemistry of lime and magnesia, undertaken with reference to the origin of the native combinations of these bases. Mention should also be made of his contributions to a chemical cosmogony and to a comprehensive theory of chemical and dynamical geology, a sketch of which will be found in his essay on "The Chemistry of the Earth," in the "Smithsonian Report" for 1869.

Dr. Hunt's numerous contributions to chemistry and geology in their technical applications relating to soils, fertilizers, peat, building-materials, the manufacture of salt, and the ores and metallurgy of iron and copper, will be found in the publications of the Geological Survey of Canada, and in part in the proceedings of the Institute of Mining Engineers. *See* also his essay on "The Coal and Iron of Southern Ohio" (Salem, 1874). A large part of the reports of the Canada Survey during twenty-five years was contributed by him, and also the latter half of the large volume entitled "Geology of Canada" (1863).

Among Dr. Hunt's later contributions to geology are his studies of "Granites and Granitic Veinstones;" "The Geognosy of the Appalachians and the Origin of Crystalline Rocks" (1871); and the "History of the Names Cambrian and Silurian in Geology" (1872). His views as to the crystalline, stratified rocks, their genesis, their great antiquity as opposed to the notion of their more recent origin, and his grouping and classification of them, undertaken after many years of research and comparison over a wider field than has been studied by any other American geologist, constitute a new departure in the science. They have attracted much attention, and, despite some attacks, are finding a wide recognition, both in this country and in Europe. The three essays just named, together with some others, on various subjects of chemical geology, including mineral waters, dolomites, gypsum, petroleum, and ore-deposits, with many notes and additions, and with selections from his papers on the philosophy of chemistry and mineralogy, have lately been published in a volume entitled "Chemical and Geological Essays" (Boston, 1875). Of this work a notice appeared in THE POPULAR SCIENCE MONTHLY, vol. vi., p. 372. It is understood that he is now preparing a "Handbook of American Geology." During the past summer he has been engaged in the new Geological Survey of Pennsylvania under Prof. Lesley.

Dr. Hunt was President of the American Association for the Advancement of Science in 1870. He is a member of the National Academy of Science, the American Philosophical Society, and the American Academy of Boston. In 1859 he was elected a Fellow of the Royal Society of London. He is a member of the Imperial Leopoldo-Carolinian Academy of Germany, and of the Geological Societies of France, Belgium, Austria, Ireland, etc. He was a member of the International Juries at the Great Expositions at Paris in 1855 and 1867, and on the latter occasion was made an officer of the Legion of Honor.

EDITOR'S TABLE.

SOUNDING A NEWSPAPER FOG.

THE readers of the MONTHLY will find elsewhere in our pages an article which appeared several weeks ago in the *Nation*, containing an attack upon Prof. Tyndall, which, from the character of its charges, and the bitterness of its tone, excited the surprise and regret of many. It was replied to by Prof. Tyndall, whose letter we also republish. It will be seen that the assault is directly met, and, in his rejoinder to Prof. Tyndall's letter, the writer in the *Nation* admits that he was in error, while his admission covers the main and most offensive imputations. But, as his further comments are calculated to continue a false impression, and as base charges always go faster and farther than their retractions, especially when considerable time elapses before they can be authoritatively contradicted, it is desirable that we should here briefly review the leading features of the case.

The charge against Prof. Tyndall, as the reader will see, is generally, that, in the third and recently-published edition of his work on "Sound," he has not done justice to the contributions of American science toward the elucidation of the subject of fog-signals. More specifically it is that, when in this country, he got information upon the subject from a paper read by Prof. Henry, went home and entered upon the investigation himself, published in his book the results of his own inquiries, and, while acknowledging that he knew generally of what had been done in America, and that it was not without influence on his conduct, yet that he ignored or "suppressed" from his summary of existing knowledge upon the subject any recognition of what had been accomplished by the United States Lighthouse Board under the direction of Prof. Henry.

Now, let us see what Prof. Tyndall's position was as avowed by himself in a statement widely published in this country months before the attack in the *Nation* was made. The August number of THE POPULAR SCIENCE MONTHLY contains, in full, the preface to the third edition of "Sound," in which the American relations of the matter are considered. A summary is there given of the experiments of Prof. Henry in regard to the penetration of fog by sound, and the performance of various instruments of American construction designed to be used as coast-signals; and the remark is added that "it is quite evident from the foregoing that, in regard to the question of fog-signaling, the Lighthouse Board of Washington have not been idle." Prof. Tyndall states, furthermore, that he had recommended American instruments for fog-signaling to the British authorities as superior to the English instruments, and that they had been adopted on his recommendation. Every fair-minded reader, upon perusal of that paper, will agree, we think, that Prof. Tyndall wrote truthfully when he said: "In presence of these facts it will hardly be assumed that I wish to withhold from the Lighthouse Board of Washington any credit which they may fairly claim."

But, having thus testified to the character, extent, and importance of American work upon this subject, Prof. Tyndall proceeds to state what in his opinion the Lighthouse Board has failed to do. He says: "My desire is to be strictly just; and this desire compels me to express the opinion that their report fails to establish the inordinate claim made in its first paragraph. It contains observations, but contradictory observations; while, as regards the establishment of any principle which should reconcile the conflicting results, it leaves our condition unimproved."

A distinction is here drawn, and again recognized in his letter, that goes to the root of the subject; the distinction, namely, between experiments on fog-signals made for direct purposes of utility, and similar experiments conducted with a view to the establishment of scientific principles. This discrimination is all-important. It is no doubt possible to have both objects more or less in view in such an inquiry; but it is also possible that either may so predominate as to characterize the respective courses of investigation, and yield very dissimilar results. Elaborate experiments may promote practical ends, and contribute little or nothing to science; or they may advance scientific knowledge without any immediate influence upon practice. It was claimed by Prof. Henry, in his Appendix to the report of the Lighthouse Board for 1874, that the researches of the board had been more extensive on this subject than those in England, as well as prior to them; but the question remains, To what purpose were they carried on? The answer to this question, defining the character and object of the inquiries, is immediately given in the statement that the American results of "practical importance" are in advance of the English. The writer in the *Nation* speaks of "American science" as bearing Baconian fruit, such as Daboll's trumpet and Brown's steam-siren. These devices and construction are, no doubt, highly important, but there is certainly a wide difference between the invention of whistles and systematic inquiries into the causes of acoustical phenomena. No one doubts the immense value to the country and to civilization of the labors directed by Prof. Henry, as chairman of the Lighthouse Board; but he has himself declared their practical character, and how broadly true is this characterization appears from a passage in a letter which he wrote to the Secretary of the Treasury, dated February 22, 1875, defending the Washington board against an attack made upon it in Congress. It is noteworthy, also, as showing that, when Prof. Henry wishes to protect himself from adverse criticism, he falls back upon the verdict pronounced by Prof. Tyndall in this very matter of fog-signals. Prof. Henry said: "The board has a standing committee on experiments which has accepted and sought to test every invention that could be supposed to aid the mariner. Many illuminants, various devices in engineering, expedients for floating aids, plans, and theories of all kinds, have received its attention. To this accusation can be opposed on behalf of the board the verdict of foreign nations, the tributes of scientific associations, and the contented judgment of maritime and commercial men from whom no complaints are received. Its buoys are excellent in their construction; its buoy-service is well performed; its light-ships are equal to any in the world; its lights are entirely satisfactory to the commercial and nautical men for whose interest they are maintained; and its fog-signals surpass, in the finding of Prof. Tyndall, who conducted a series of experiments for the Trinity House Board, those of all other nations, and have been adopted for England." But it is claimed that Prof. Henry's investigations constitute also an important contribution to "American science," in relation to fog-signaling. Prof. Tyndall denies that they have at all advanced our scientific knowledge upon the subject, and the writer in the *Nation* had this denial before him when he wrote. It was his plain business, then, to disprove it if he could, and give the evidence that Prof. Tyndall was in error.

The simple question is, What new scientific principles have been established, or what causes elucidated by

Prof. Henry's investigations, constituting an advance of scientific knowledge in this branch of acoustics, that Prof. Tyndall has omitted or "suppressed" in his work? If any thing has been accomplished in this country toward the scientific solution of such acoustical problems in relation to fog-signaling—if any new light has been cast upon the phenomena that explains anomalies and reconciles contradictions, which was not acknowledged by Prof. Tyndall in his book—we submit that it was the obvious duty of the writer in the *Nation* to point out what it was. He should have indicated the gap in Prof. Tyndall's summary of the present state of knowledge, or he should have shown us what principles or results, there stated, are due to American research. He says: "It is no part of our present purpose to institute a critical inquiry into the conflicting views of Prof. Henry and of Prof. Tyndall with regard to the hypotheses respectively espoused by each for the explanation of the phenomena of sound, in its passage through wide tracts of air." Yet the whole question turns on the scientific "views" contributed by Prof. Henry which it is alleged that Tyndall has ignored. He speaks of the views "respectively espoused" by the parties; but the question is on the views *originated.* Prof. Henry is understood to adopt the theory propounded by Prof. Stokes at the British Association in 1857, according to which sound-waves are tilted through the air under the influence of wind. That theory is certainly not "suppressed" from the new edition of "Sound." In his rejoinder to Prof. Tyndall's letter, the *Nation's* critic reaffirms his assertion, saying, "The question between us is not one of *science*, but of *historical fact.*" But his complaint in the first article was certainly of the non-recognition of "American science." Obviously Prof. Tyndall had to decide what is science and what is not, which looks to us very much like a scientific question. In his "summary of existing knowledge," it was not his business merely to chronicle experiments. He had to deal only with such systematic inquiries into causes as yield results properly entitled to take their place in the body of scientific knowledge. We do not say that Prof. Henry's researches have failed to extend the domain of positive scientific knowledge, but only that the writer in the *Nation* was bound to establish this, before accusing Prof. Tyndall of delinquency in not recognizing it.

But it is the closing passage of the *Nation's* article which has excited the greatest surprise, betraying, as it obviously does, a vicious state of feeling on the part of the writer. He there represents Prof. Tyndall as having claimed to demolish the authority of Prof. Henry, and as swaggering over the "ruin" he had accomplished. In half a dozen lines, Tyndall is accused of "superciliousness," "self-complacency," "vanity," "conceit," "arrogance," and "self-laudation;" and this upon an utterly false and absurd interpretation of some incidental remarks in his preface. The following is the passage that called forth this storm of offensive epithets:

> "The clew to all the difficulties and anomalies of this question is to be found in the aërial echoes, the significance of which has been overlooked by General Duane, and misinterpreted by Prof. Henry. And here a word might be said with regard to the injurious influence still exercised by authority in science. *The affirmations of the highest authorities, that from clear air no sensible echo ever comes, were so distinct, that my mind for a time refused to entertain the idea.* On the day our observations at the South Foreland began, I heard the echoes. They perplexed me. I heard them again and again, and listened to the explanations offered by some ingenious persons at the Foreland. They were an 'ocean-echo;' this is the very phraseology now used by Prof. Henry. They were echoes 'from the crests and slopes of the waves;' these are the words of the hypothesis which he now espouses. Through a portion of the month of May,

through the whole of June, and through nearly the whole of July, 1873, I was occupied with these echoes; one of the phases of thought then passed through, one of the solutions then weighed in the balance and found wanting, being identical with that which Prof. Henry now offers for solution.

"But though it thus deflected me from the proper track, shall I say that authority in science is injurious? Not without some qualification. It is not only injurious, but deadly, when it cows the intellect into fear of questioning it. But, the authority which so merits our respect as to compel us to test and overthrow all its supports before accepting a conclusion opposed to it, is not wholly noxious. On the contrary, the disciplines it imposes may be in the highest degree salutary, though they may end, as in the present case, in the ruin of authority. The truth thus established is rendered firmer by our struggles to reach it."

A correspondent of the *Nation* from Baltimore, quoting the above passage, characterizes the "glaring injustice" of the concluding portion of its article, and adds: "Any candid reader can see that the passage on which your reviewer bases such serious imputations cannot possibly bear the interpretation which every one reading it as given in your review is compelled to put upon it. Prof. Tyndall never indicates that it was the authority of Prof. Henry that impeded him in his researches." The sentence italicised in the extract upon the previous page is perfectly conclusive in showing what Prof. Tyndall did mean by the authority which embarrassed him until he rejected it.

In his letter Prof. Tyndall puts an end to the charge, so that the *Nation* is compelled to acknowledge itself "in error in supposing that the claim of Dr. Tyndall to have ruined authority was aimed at Prof. Henry." One would think that, when the *Nation's* critic had been convicted of blundering by a correspondent, and when his fabric of detraction had been so effectually demolished by Prof. Tyndall himself that the writer was compelled to back out of it, he would have had the grace to drop the subject. But, on the contrary, he renews the insulting imputation. Having made a slanderous charge entirely upon the assumption that Prof. Tyndall was exulting in the ruin of Prof. Henry's authority, and having barbed his article with this libel, when it was swept away, he says: "It would have been more in order for him to show the propriety of his language in claiming to have 'ruined' the 'authority' of any one among his scientific predecessors, for it was on the alleged self-conceit implied in such a claim as made by himself that we based our 'peroratory invective.'"

Now, we aver that there is nothing in the passage quoted that is open to the offensive construction here put upon it, and which never would have been thought of, but for the unscrupulous distortion of its meaning by the *Nation's* critic; but that the real import of the extract is entirely contrary to that which has been ascribed to it. That which was written to enforce the lesson of cautious self-examination and circumspection in dealing with the mental difficulties of scientific research is wrested into an opposite expression of arrogance and self-conceit. It is not to be forgotten, here, that the scientific man, to the extent of his originality and power, is a questioner of things established. His attitude is that of an enemy of authority. It is his recognized business, as evinced by the common forms of speech, to "subvert" authority, to "break down" authority, to "overthrow," "crush" and "ruin" authority. Call the motive which impels the man of science what you please, the fact remains that in virtue of his being a man of science, aiming to arrive at new views, he is a destroyer of authority. But just because this is his necessary work he is in danger from the state of mind it produces; and it becomes important not to forget that there is good as well as bad in authority. Prof. Tyndall simply intimated the need there is that the inquirer should be on his guard. Every one familiar with his writings is aware that he differs from most of his scientific colleagues by looking habitually from the subject he is investigating to the working of his own mind in the investigation, and by frequently throwing parenthetical remarks of a philosophical, rather than of a strictly scientific significance, into his expositions. The interjected observations about authority in the preface are clearly of this kind. In his "Lectures on Light," second edition, page 80, he remarks: "Newton's espousal of the emission theory is said to have retarded scientific discovery. It might, however, be questioned whether, in the long-run, the errors of great men have not really the effect of rendering intellectual progress rhythmical, instead of permitting it to remain uniform, the retardation in each case being the prelude to a more impetuous advance. It is confusion and stagnation rather than error that we ought to avoid." Now, the underlying thought in the passage from the preface above quoted is manifestly the same as that here expressed. The object in both cases is, simply to bring out the uses of authority, and no candid reader will recognize any element of "self-laudation" in the one case any more than in the other.

It has hitherto been thought that, as discoveries are the result of mental operations, science is always the gainer, when an intelligent account is given of the intellectual processes by which a new result is reached; but it now seems that if one refers to his own thoughts he must expect to be snubbed as an egotist. And, particularly, if he attains conclusions of moment, involving the upsetting of former theories, and where it is of increased importance to know the mental operations that lead to them, he will be pretty certain to find some mocking cynic who will twit him with his "self-consciousness, explaining to itself and to others how it grew so great." It is a little comical, however, to take lessons in humility from a writer who mounts the judgment-seat and exhausts the vocabulary of abuse in depreciating others; or to listen to homilies on modesty from a journal that sets up each week to criticise all that is going on in the universe—while both are convicted of detraction on the basis of the most brazen perversions.

"*THE CONFLICT OF AGES.*"

We ask careful attention to the argument of President White on the "Warfare of Science," the first installment of which opens the present number of the Monthly, and the second of which will appear in our next issue. The import of his clear-cut thesis, and the vigor, learning, and logical force, with which it is sustained, will command the admiration of all intelligent students of the subject. But that which makes President White's discussion unique, and especially valuable, at this time, is the copious notes and references by which it is enriched and fortified, and which open the way to the whole literature of the question for the benefit of those who desire to consult the original authorities. At this time, when the hot temper of controversy leads to much random and reckless statement, it is desirable to know, very clearly, what can be proved, and where the proof can be found: President White's article is, therefore, opportune, and will be especially valued at present, while it must also take its place as a permanent contribution to a question which is bound to be of increasing interest in the future.

That we may not be accused of partiality or injustice to opposite views, we print also, in this number, an elaborate and earnest argument, delivered at the inauguration of Vanderbilt University, by Dr. Deems, on the other side of the question. The address is liberal in spirit, and often bold in its concessions, but we can hardly assent to its opening declarations. The author maintains that "the recent cry of 'the Conflict of Religion and Science' is fallacious and mischievous to the interests of science and religion, and would be most mournful if we did not believe that, in the very nature of things, it must be ephemeral. Its genesis is to be traced to the weak foolishness of some professors of religion, and to the weak wickedness of some professors of science."

On the contrary, we consider this conflict to be natural and inevitable, to be wholesome rather than mischievous; and having convulsed the world for centuries, and being still rife, with little prospect of speedy adjustment, we hardly see how it can be regarded as "ephemeral." Nor can it be much dependent upon the attributes here assigned to some of the controversialists. If the said professors of religion were brayed in a mortar until all their folly departed from them, and the said professors of science were all regenerated, the relations of the subjects would still give rise to hostility, and raise up new antagonists. No truce among the leaders can affect the deeper issues as viewed by the general mind. Something ought to be learned from experience, and that there has been a long and fierce antagonism between what has passed under the name of religion, and what has passed under the name of science, is sufficiently shown from the evidence furnished by President White. That the antagonism continues, is not because of the wrong-headedness of a few partisans who are bent upon stirring up strife, but because science is driving on with its researches, regardless of any thing but the new truth it aims to reach, while the religious world is full of anxiety and dread about what is going to happen as a consequence of this uncontrollable movement. Those who think the existing phase of the alleged conflict illusive are requested simply to consider the attitude of mind of the great mass of devout and sincerely religious people toward the more advanced scientific conclusions and scientific men of the present day. It is no test of the matter to determine how the great body of religious people now regard the science established in former times. The religious liberality of each age is put upon its trial by the questions arising in each age. In our own time biology is the branch of science that is most progressive and occupies the attention of, perhaps, the largest number of investigators who are busy inquiring about the origin of life, the antiquity of man, cerebral psychology, the laws of force manifested in living beings, and the evolution of organic forms in the course of Nature. How are such inquiries regarded by the multitude of devoutly religious people? Are they not considered "dangerous?" Are they not viewed by this class exactly as the new doctrines in astronomy and geology were viewed by the same class in former times, that is, as hostile to faith and subversive of religion? Is there no conflict here? Are the brand of "materialism" which is put upon biological study in our times, and the charge that a materialistic science is aiming to cut up religion by the roots, indicative of harmony between these parties? Science must go on, and, if her results thus far are bad, there is no prospect that they will be better in the future. There can be only one basis of substantial peace, and that is the entire indifference of religious people, *as such*, to the results of scientific inquiry. This they cannot attain until far better instructed than at present; and we apprehend that it will take very considerable time to reach that desirable consummation.

END OF THE PENIKESE SCHOOL.

THE proposition made three or four years ago, and due, as we understood, to Prof. Shaler, to establish a School of Natural History at Nantucket for the benefit of the teachers of the country, and at the time of their vacation, we thought one of the most feasible and important educational movements of the time. The plan was comprehensive, involving the services of some twenty lecturers who were masters of the several departments of natural history; and it was received with such favor throughout the country, that it was certain a very large number of students would have collected there to avail themselves of the superior instruction that could have been afforded. The island, besides, was conveniently accessible, and the accommodations offered by the town ample, excellent, and moderate in price. There was, in short, large practical promise in the enterprise.

But it was not carried out, and in its stead there grew up another school in natural history, under the auspices of Messrs. Agassiz and Anderson, on another island, difficult of access and without accommodations. But few pupils could be taken, and the large expenses of the experiment, under the peculiar circumstances, had to be defrayed from without. The necessary funds not being forthcoming, the project collapsed, and the school is numbered among the things that were. Much regret has been expressed at the result; but we shed few tears over the failure of the Penikese School. Why should money be wasted in sustaining a school in an ill-chosen station that limits its usefulness and entails inordinate expense? We observe that the editor of *Nature*, in announcing the abandonment of the institution, and explaining the unpleasant controversy that accompanied it between Mr. Anderson, the donor of the island, and the trustees, speaks in a tone of strong regret at the result. He thinks it unfortunate that Mr. Anderson had not contributed a little more money, as, "had he done so, those interested in the success of the school would have had time to set about raising something like an endowment fund, and *a fine opportunity would have been afforded to the United States Government to show their appreciation of practical scientific teachers and scientific research.*" The italics here are our own, and the suggestion they convey admirably illustrates the easy tendency and universal readiness there is to go to Government for help to sustain every thing that cannot be sustained by the appreciation and liberality of the community. A school absurdly located, costly, and restricted, is not supported by the public—with all its appreciation of education and readiness to contribute to it whenever its contributions are wisely expended—and so the state is invoked to assume the burden due to bad calculations. We think it is a good deal better that the concern should have been wound up than to have dragged along in a precarious way, or got a subsidy from the Legislature, as it will perhaps cease to be a hindrance to the organization of other schools in better circumstances.

THE EDUCATION QUESTION AT MONTPELLIER.

THERE are many indications of a very serious struggle, almost coextensive with civilization, between ecclesiastical authority and the liberal spirit of the age on the subject of education. Religion may not be responsible for it, but religious bodies are involved in it, and it threatens to become a matter of increasing difficulty, notwithstanding our vaunted enlightenment and the success of free government. The most numerous sect of Christendom has its own policy on the subject of education, and clings to it invincibly, though with a wise discretion in the avowal of its claims. The passages given in the following letter are an undisguised statement of the demands of the Romish Church as to its right to educate mankind.

The following letter from Prof.

Tyndall, bearing upon this subject, lately appeared in the London *Times:*

"A learned French friend has favored me with a copy of a letter recently published in France, and bearing the following title: 'Letter of Monsignor the Bishop of Montpellier to the Deans and Professors of the Faculties at Montpellier.' Its date is the 8th of this month of December, 1875. One or two extracts from it may not be without their value for the people of England and of America, to whom, in our day, has fallen the problem of education in relation to the claims of Rome.

"The bishop writes to the deans and professors aforesaid:

"'Now, gentlemen, the holy Church holds herself to be invested with the absolute right to teach mankind; she holds herself to be the depositary of the truth—not a fragmentary truth, incomplete, a mixture of certainty and hesitation, but the total truth, complete, from a religious point of view. Much more, she is so sure of the infallibility conferred on her by her Divine Founder, as the magnificent dowry of their indissoluble alliance, that even in the natural order of things, scientific or philosophical, moral or political, she will not admit that a system can be adopted and sustained by Christians, if it contradict definite dogmas. She considers that the voluntary and obstinate denial of a single point of her doctrine involves the crime of heresy, and she holds that all formal heresy, if it be not courageously rejected prior to appearing before God, carries with it the certain loss of grace and of eternity.

"'As defined by Pope Leo X., at the Sixth Council of the Lateran, "Truth cannot contradict itself; consequently, every assertion contrary to a revealed verity of faith is necessarily and absolutely false." It follows from this, without entering into the examination of this or that question of physiology, but solely by the certitude of our dogmas, we are able to pronounce judgment on any hypothesis which is an anti-Christian engine of war rather than a serious conquest over the secrets and mysteries of nature.'

"Liberty is a fine word, tyranny a hateful one, and both have been eloquently employed of late in reference to the dealings of the secular arm with the pretensions of the Vatican. But 'liberty' has two mutually exclusive meanings—the liberty of Rome to teach mankind, and the liberty of the human race. Neither reconcilement nor compromise is possible here. One liberty or the other must go down. This, in our day, is the 'conflict' so impressively described by Draper, in which every thoughtful man must take a part. There is no dimness in the eyes of Rome as regards her own aims; she sees with a clearness unapproached by others that the school will be either her stay or her ruin. Hence the supreme effort she is now making to obtain the control of education; hence the assertion by the Bishop of Montpellier of her 'absolute right to teach mankind.' She has, moreover, already tasted the fruits of this control in Bavaria, where the very liberality of an enlightened king led to the fatal mistake of confiding the schools of the kingdom to the 'doctors of Rome.'

"Your obedient servant,

"JOHN TYNDALL.

"ATHENÆUM, *December* 16, 1875."

The University of Montpellier, to the deans and faculties of which the above notification is addressed, is one of the oldest and most honored universities of Europe. It was founded in the twelfth century, its medical faculty by the Spanish Arabs. Situated in what was formerly called Languedoc, one of the southern portions of France, it has a botanical garden, the first that was established in Christendom. Its Observatory has for ages been in repute, its Museums of Natural History and Fine Art have long been celebrated. It has made its city one of the intellectual centres of France.

In this university was first translated into Latin Ptolemy's great Greek work, the "Alma Gest." One of the regents was the first European to make tables of the moon, and to determine the obliquity of the ecliptic. He is honorably mentioned by Copernicus. In literature it is distinguished by being the seat of the earliest cultivation of a modern language. From the romance literature of Langue d'Oc, Petrarch and Dante took their inspirations.

But in another respect it has a memorable celebrity. Here the Inquisition was first organized, and Languedoc was the seat of the most dreadful persecutions that the world has ever witnessed. Thousands of persons were put to death, whole cities were burnt. The French Protestantism of the middle ages was extinguished by fire and sword. The professors and doctors of the university were expelled from the country.

Six centuries have not sufficed to abate this ecclesiastical bigotry. There is the Bishop of Montpellier claiming for his Church the exclusive right to teach mankind. He leaves no doubt as to what sort of teaching it would be. Nothing inconsistent with the dogmas of the Church. None of your astronomy, or geology, or physiology, or other atheistic sciences. Let American colleges and universities lay this thing to heart! Their turn may some day come.

LITERARY NOTICES.

The Nature of Light, with a General Account of Physical Optics. By Dr. Eugene Lommel, Professor of Physics in the University of Erlangen. With 188 Illustrations. D. Appleton & Co. No. XIX. "International Scientific Series." Pp. 356.

A book has long been wanted, making clear to the popular mind the most interesting and important principles of the beautiful science of optics. The subject is usually treated in a meagre way as a subdivision in our text-books of physics, and, even in the largest of these, the discussion of light is usually very incomplete. But no subject is more worthy of separate treatment, and Dr. Lommel has made a volume well worthy of its position in the "International Scientific Series." An interesting portion of one of his chapters, that dealing with the curious and wonderful phenomena of fluorescence, is given in our present number, furnishing a fair illustration of the clearness of the author's writing and the freshness of his presentation.

In an elaborate notice of the work, which appeared in *Nature*, it is remarked: "In the present treatise, Prof. Lommel has given an admirable outline of the nature of light and the laws of optics. Unlike most other writers on this subject, the author has, we think wisely, postponed all reference to theories of the nature of light, until the laws of reflection, refraction, and absorption, have been clearly set before the reader. Then, in the fifteenth chapter Prof. Lommel discusses Fresnel's famous interference experiment, and leads the reader to see that the undulatory theory is the only conclusion that can be satisfactorily arrived at. A clear exposition is now given of Huyghens's theory, after which follow several chapters on the diffraction and polarization of light-bearing waves. The reader is thus led onward much in the same way as the science itself has unfolded, and this, we think, is the surest and best way of teaching natural knowledge."

Mind: A Quarterly Review of Psychology and Philosophy. No. I., January, 1876. Pp. 156. Price $1.00, subscription $4.00 a year. Republished by D. Appleton & Co., New York.

We have here the promise of a periodical new in its plan, broad and important in its scope, and very ably sustained. It represents the new departure in psychological study, from the point of view taken by Bain and the modern school; in fact, the project of its establishment is largely due to Prof. Bain himself, who will have an active share in its management, although the responsible editor is Prof. George Croom Robertson, of University College, London. The range and quality of this work will be best gathered from the following passages taken from the prospectus:

> "MIND will be an organ for the publication of original researches, and a critical record of the progress made in Psychology and Philosophy.
>
> "Psychology, while drawing its fundamental data from subjective consciousness, will be understood in the widest sense, as covering all related lines of objective inquiry. Due prominence will be given to the physiological investigation of Nerve-structures. At the same time, Language and all other natural expressions or products of mind, Insanity and all other abnormal mental phases, the Manners and Customs of Races as evincing their mental nature, mind as exhibited in Animals generally—much of what is meant by Anthropology, and all that is meant by Comparative Psychology—will come within the scope of the Review.
>
> "The practical application of psychological theory to Education will receive the attention it so urgently claims at the present time.
>
> "Beyond Psychology, account will be taken of Logic, Æsthetics, and Ethics, the theory of mental functions being naturally followed by the doctrine of their regulation.
>
> "For the rest, MIND will be occupied with general Philosophy. Even as a scientific journal, it cannot evade ultimate questions of the philosophical order, suggested as these are with

peculiar directness by psychological inquiry. There is, also, a function truly philosophical which only the investigator of mind is in a position to discharge, the task, namely, of collating and sifting the results of the special sciences with a view alike to insight and conduct. But MIND will, further, expressly seek to foster thought of bold sweep—sweep that can never be too bold, so be that it starts from a well-ascertained ground of experience, and looks to come again there to rest."

The first number well justifies the promises here made, and there is every reason to believe that the succeeding issues will do so in a still greater degree.

Report of the Forty-fourth Meeting of the British Association for the Advancement of Science: held at Belfast, in August, 1874. London: John Murray, 1875.

One of the most valuable features of the yearly volumes of the British Association is the publication of extended "Reports on Researches in Science," which are annually made on special subjects by small committees of eminent men who are themselves working in those subjects. Thus, in the volume before us, there are no less than *thirty* such reports, occupying about 360 octavo pages. The Association often aids in an investigation by the appropriation of a small sum of money, and in return it receives a report on the progress of the work, besides the gratification of having assisted some research that otherwise might have been long delayed.

For instance, since 1848 reports have been given upon the observations of Luminous Meteors, which contain nearly all the known facts relating to meteorites, arranged in an orderly form, and in some degree sifted. This report for 1873–'74 contains 90 pages.

Reports on Earthquake Phenomena, on Tides, on the Waves of the Atmosphere, on Magnetic and Meteorological Observations, and many other similar subjects, are to be found in the pages of the past volumes, and often the facts of such reports are collected nowhere else. From the present volume we extract almost at random the titles of a few of these reports, which may serve to show the nature of the subjects which are yearly brought to the attention of the meetings: "Report on the Recent Progress and Present State of Systematic Botany" (27 pages); "On the Rainfall of the British Isles for 1873–'74" (43 pages); "On the Treatment and Utilization of Sewage" (14 pages); "On Cyclone and Rainfall Periodicities in Connection with Sun-spots" (23 pages); "On the Erratic Blocks of England and Wales" (8 pages); "On Instruments for measuring the Speed of Ships" (9 pages), etc. The committees making these reports counted among their members the most eminent men of England—Lyell, Lubbock, Boyd-Dawkins, Bentham, W. K. Clifford, Balfour Stewart, Clerk-Maxwell, Huxley, Galton, Sir William Thomson, Huggins, Lockyer, De la Rue, and many others scarcely less known. With such subjects reported on by so eminent specialists, it is easy to see how these reports have come to have so high a value.

The Belfast meeting was attended by nearly 2,000 members, and over £2,000 was received from fees, etc.; £1,080 was appropriated for scientific purposes; £400 for various works of the section of mathematics and physics (printing mathematical tables, rainfall and meteor reports, thermo-electricity, etc.); £155 for researches in chemistry; £280 for various geological explorations; £170 for biology; £100 for the Palestine Exploration Fund; £25 for statistics (economic effect of combinations of laborers or capitalists); and £50 for instruments for measuring the speed of ships. This abstract will give some idea of the practical benefit to science which the Association gives, and it is also instructive as showing for what purposes its money is spent.

The last 232 pages of the volume are devoted to an abstract of the proceedings of the sections. We find that the section of mathematics and physics occupies 44 pages, the chemical section has 22 pages, geological 29 pages, biological 64 pages, geographical 24 pages, statistical 27 pages, and finally that the mechanical section occupies 20 pages. In a rough way this shows the amount of attention paid to the various branches at the 1874 meeting, and it is accurate enough to indicate the great amount of work now doing in biology in England, which is a noteworthy feature of this and preceding reports.

STRENGTH OF BEAMS UNDER TRANSVERSE LOADS. By W. ALLAN. Pp. 114. Also **SEWERAGE AND SEWAGE UTILIZATION.** By W. C. CORFIELD, M. A. New York: Van Nostrand. Pp. 128. Price, 50 cents each.

IN the first of these two little volumes the practical builder will find a discussion of the most important and common cases of horizontal beams under vertical loads. The problems are worked out without having recourse to the higher mathematics. The second volume contains, in abridged form, a series of lectures delivered by Prof. Corfield before the School of Military Engineering at Chatham, England. The question of sewerage and sewage utilization is one of the urgent problems of modern life, and it yet awaits satisfactory solution. Meanwhile, Mr. Van Nostrand does the public a service by placing within the reach of all the views of so eminent an engineer as Prof. Corfield upon these subjects.

NOTES OF THE MANUFACTURE OF POTTERY AMONG SAVAGE RACES. By CH. FRED. HARTT, A. M. Pp. 70. Rio de Janeiro: *South American Mail* print.

PROF. HARTT here, in the first place, briefly considers the question of the origin of the ceramic art. When, where, how did it originate? No positive answer can be given to these questions. Like other human arts, it is the result of a long evolution, and its simple beginnings we may never be able to find out. So much, however, is certain, namely, that the finest porcelain wares are the true lineal descendants from the pottery of the savage. The author next considers the materials employed and the methods followed in the building of a vessel. Before the advent of Europeans, pottery in America was made by hand, the potter's wheel being unknown. He finds the method of fashioning vessels out of coils of clay widely practised in South America. The manufacture is everywhere exclusively in the hands of the women.

THE DIFFERENCE OF THERMAL ENERGY TRANSMITTED TO THE EARTH BY RADIATION FROM DIFFERENT PARTS OF THE SOLAR SURFACE. Pp. 10.

THIS is a reprint of a communication in *Nature* by Mr. John Ericsson, in which he points out defects in Father Secchi's method of measuring the intensity of the sun's radiant heat. Secchi's method is that of projecting the sun's image on a screen, and then measuring the temperature at different points by means of thermopiles. Ericsson adopts the method of *direct* observation, and employs a special apparatus devised by himself. Mr. Ericsson estimates the absorption by the solar atmosphere at not over 0.144 of the radiant heat emanating from the photosphere. The intensity of radiation from the border of the sun he estimates at 0.638 of the intensity of radiation from an equal area of the central region.

CHECK-LIST OF NOCTUIDÆ OF AMERICA, NORTH OF MEXICO. By A. R. GROTE, A. M. Pp. 28, with Plate. Price, $1. Buffalo, N. Y.: Reinecke & Zesch.

OF the twelve hundred North American species of *Noctuæ*, less than thirty, we are informed by Mr. Grote, are considered identical with European forms. The facts seem to point to a common origin of many of the forms, and it is the author's opinion that the European and North American *Noctuæ* are in part descended from species living over a common territory, and that the Glacial epoch separated the stocks. The list of species here given includes a complete synonymy of the *Noctuidæ* of America north of Mexico, so far as known. It is invaluable to the student of entomology.

STATE MEDICINE IN ITS RELATIONS TO INSANITY. By Dr. NATHAN ALLEN. Pp. 31.

DR. ALLEN considers the subject of insanity in the six New England States. He finds that in Massachusetts, from 1850 to 1870, the increase of insanity was 12 per cent. greater than the increase of population, and the same is to be said of the other New England States. He favors consigning the chronic insane to *homes*, instead of keeping them in hospitals. What they need is, not medical treatment, but suitable exercise, sunlight, air, proper nourishment, etc. He also advocates the adoption by the State of measures for the *prevention* of insanity. The dissemination of more correct views of the true way of living and a more rigid observance of the laws of health and Nature would, no doubt, greatly diminish the frequency of mental disease.

The New Method of Graphical Statics. By A. J. Du Bois, C. E., Ph. D. 60 Illustrations. Pp. 80. Price, $2. New York: Van Nostrand.

This book is made up of a series of articles which appeared originally in Van Nostrand's *Engineering Magazine*. The author's object is to win more general attention to a new method for a graphical solution of statical problems, which, during the last ten years, has been gradually developed and perfected, and which offers to the architect, civil engineer, and constructor, a simple, swift, and accurate means for the solution of a great number of practical questions.

Report upon the Condition of Affairs in Alaska. By H. W. Elliott. Washington: Government Printing-Office. Pp. 277.

In 1874 Mr. Elliott was directed by the Treasury Department to visit Alaska, for the purpose of studying and reporting upon the present condition of the seal-fisheries; the haunts and habits of the seal; the preservation and extension of the fisheries; the statistics of the fur-trade; and the condition of the natives. The results are contained in the volume before us. The work is full of valuable information. It is divided into nine chapters, treating of the "Character of the Country;" "Condition of the Natives;" "Duty of the United States Government;" "Trade and Traders;" "The Sea-Otter;" "The Seal-Islands;" "Habits of the Fur-Seal;" "The Sea-Lion;" "Fish and Fisheries;" and the "Ornithology of the Prybilov Islands."

Our Wasted Resources. By William Hargreaves, M. D. New York: National Temperance Society. Pp. 201. Price, $1.25.

Dr. Hargreaves quotes statistics to show that, in 1873, the income of the people of the United States exceeded $7,000,000,000. He thinks that, to the use of intoxicating drinks, nearly all of the crime and pauperism of the country is to be attributed. He compares the cost of intoxicating liquors with the total receipts of sundry industries; sums up the losses of the country from the trade in liquors; tries to show that the use of liquors and the liquor-trade destroy the influence of education. Finally, he lays down the proposition that "the use of and the traffic in strong drinks impede the progress of the Christian Church, and the spread of the gospel."

Notes of Travel in Africa. By C. J. Andersson. New York: Putnam's Sons. Pp. 318. Price, $2.00.

There appears to exist in the public mind a genuine interest in the exploration of Africa, and the number of books of African travel published within the last ten years is enormous. The writings of C. J. Andersson have in no small measure contributed to the awakening of this curiosity, and doubtless the present work, made up from the memoranda of that distinguished traveler, will be read with the same eagerness as his earlier publications.

Dissertations and Discussions. By J. Stuart Mill. New York: Holt & Co. Pp. 294. Price, $2.50.

This is the fifth volume of the "Dissertations and Discussions," and it completes the series. It contains five papers on "Land Tenure;" also essays on "Endowments;" on "Labor;" on "Treaty Obligations;" on Maine's "Village Communities;" Taine's "Intelligence;" Grote's "Aristotle;" Baer's "L'Avere e l'Imposta;" and Leslie's "Land Question."

A Practical Treatise on Soluble Glass. By Dr. Lewis Feuchtwanger. Pp. 164. New York: L. Feuchtwanger & Co.

The author points out the manifold uses of soluble glass, for instance, as a means of preserving timber and making it non-inflammable; as an ingredient in the composition of artificial stone; for mixing with paints to be applied to the surface of metals, glass, and porcelain; in soap-making; in calico-printing, etc.

Report of the Commissioner of Education for 1874. Pp. 935.

Contains, in addition to the observations and suggestions of the commissioner, a great mass of statistics relating to the state of education throughout the country in the year 1874.

Dr. Draper's "Conflict."—There have been published of Dr. Draper's book, "The Conflict," eight editions in America, and five in London. It has been translated into French, and is in its third edition in Paris. The German translation made by Dr. Rosenthal has had a similar success. A Polish translation has been made in the University of Warsaw; a Servian one by Prof. Meta Rakitch, in Belgrade. The Spanish translation is by Señor Arcemis, the astronomer of Cadiz. The Russian is under examination by the censorship.

PUBLICATIONS RECEIVED.

Exploration of the Colorado River of the West. By Major J. W. Powell. Washington: Government Printing-Office. Pp. 291, with Maps.

Science By-ways. By R. A. Proctor. Philadelphia: Lippincott. Pp. 422. Price, $4.00.

Selection and Use of the Microscope. By J. Phin. New York: Industrial Publication Co. Pp. 131. Price, 75 cents.

Report on the Wisconsin Institution for the Blind, 1875. Madison, Wis.: E. B. Bolens. Pp. 20.

Bulletin of the United States National Museum, No. 2. Washington: Government Printing-Office. Pp. 50.

American Journal of Microscopy. Monthly. New York: Industrial Publication Co. 50 cents per year.

Forms of Life found in the Oral Cavity. By C. N. Peirce, D. D. S. Lancaster, Pa.

Pennsylvania Journal of Dental Science. Pp. 23.

Bridge and Tunnel Centres. By J. B. McMaster. New York: Van Nostrand. Pp. 106. Price, 50 cents.

Scientific Monthly. E. H. Fitch, Editor and Publisher. Toledo, O.: Pp. 96. Price, $3.00 per annum.

Geological Notes. By W. B. Rogers. Pp. 13.

Circulars of the Bureau of Education. Washington: Government Printing-Office. Pp. 130.

Vick's Floral Guide for 1876. Rochester, New York: Vick & Co. Quarterly, 25 cents per year.

Geological Survey of Minnesota, 1874. By N. H. Winchell. St. Paul: *Pioneer Press* print. Pp. 36, with Maps.

Transactions of the American Society of Civil Engineers, 1875. Pp. 49.

Safety-Valves. By R. H. Buell. New York: Van Nostrand. Pp. 100. Price, 50 cents.

Mammoth Cave of Kentucky. By W. S. Forwood, M. D. Philadelphia: Lippincott. Pp. 241, with Illustrations.

Three Months in Old Hospitals of Paris. By R. Ludlam, M. D. Philadelphia: Sherman & Co. Pp. 16.

Report of the United States Treasurer, 1875. Washington: Government Printing-Office. Pp. 67.

Post-Nasal Catarrh. By B. Robinson, M. D. New York: Trow & Son. Pp. 29.

Does Matter do it all? By Epes Sargent. Boston: Colby & Rich. Pp. 16.

Zappus Hudsonius, and Lagopus Leucurus. By E. Coues. Washington: Government Printing-Office. Pp. 10.

Necessity of a Mechanical Laboratory. By R. H. Thurston. Philadelphia: W. P. Kildare, Printer. Pp. 10.

MISCELLANY.

Relations of Chemistry to Pharmacy and Therapeutics.—We present herewith the main points of an instructive address delivered by Dr. T. Sterry Hunt before the Massachusetts College of Pharmacy, on "The Relations of Chemistry to Pharmacy and Therapeutics."

With the eighteenth century is connected the birth of modern chemistry; and, while Priestley and Lavoisier are honored as having given a new impulsion to chemical theory, the Swedish apothecary Scheele will always be remembered as one who probably enriched the science with more discoveries than either of them. The three brightest names on the roll of great chemists in our century have been gathered from the ranks of the pharmaceutical profession, viz., Davy, Liebig, and Dumas. But the debt owed by chemistry to pharmacy has been amply repaid: the labors of the chemist have transformed the pharmaceutical art, replacing empiricism by science, enriching the materia medica with a vast number of new substances, and introducing new processes. Such old-fashioned drugs as coral, egg-shells, and the like, were shown by the chemist to possess no other value than belongs to the calcareous salts of which they are chiefly composed. Iodine was shown to be the active principle in the drug, calcined sponge; and henceforth iodine takes the place of the crude and bulky residue from the burning of sponge. In like manner quinine and morphine replaced cinchona-bark and opium.

In cases where the medicinal virtues are not apparently lodged in a single principle capable of being isolated, pharmacy has recourse to other processes, and obtains by expression, percolation, and evaporation, or distillation, often *in vacuo*, concentrated extracts which enable us to dispense with the crude drugs. Thus, for a rough example, by means of the sulphide of carbon the subtile perfumes of the violet and jasmine have been isolated. The artificial formation of urea and valerianic and benzoic acids opened up a new field for chemistry and pharmacy. By a careful dissection, as it were, of certain organic principles, we have learned to reconstruct them; and the triumphs of this method are seen in the artificial production of indigo, orcine and alizarine, and the odorant principle of vanilla. What wonder, then, that the chemist should now aspire to produce, artificially, the active principles of the poppy and cinchona, and render cheaper those precious drugs, morphine and quinine? These problems are destined to be solved at no distant day.

The history of anæsthetics is next traced by the author from the discovery of the physiological action of nitrous oxide by Davy to that of chloral by Liebreich. From this he passes to the subject of the chemical changes undergone by drugs in the animal economy, and the relations of these changes to physiological action. The mineral salts of many of the metals, such as sulphates and chlorides, act, to a great extent, like foreign substances when taken into the stomach, forming insoluble compounds with albuminous matters; but, when combined with certain organic acids, these metals are in a condition favorable to absorption. Thus, it is that the citrates, tartrates, and lactates of bismuth, antimony, iron, etc., are now advantageously employed in medical practice.

It having occurred to a chemist that salicylic acid might be antiseptic like carbolic acid, he made experiments which resulted in showing that in this almost tasteless body we possess an antiseptic agent of great power.

The immense advance made in the pharmaceutical art and the constant contributions brought to it by chemistry demand each year a higher education for the profession of pharmacy, and the day cannot be far distant when the need of a regular training and a thorough scientific education will be held to be as indispensable for the pharmacist as for the physician and the surgeon.

Haeckel on Scientific Institutions.—In his latest book ("Ziele und Wege der heutigen Entwickelungsgeschichte") Prof. Haeckel, the great apostle of Evolution in Germany, announces the discovery of the following law: "In all the magnificent scientific institutes founded in America by Agassiz, the following empirical law, long recognized in Europe, has been confirmed, viz.: that the scientific work of these institutes and the intrinsic value of their publications stand in an inverse ratio to the magnitude of the buildings and the splendid appearance of their volumes. . . . I need only refer," he adds, "to the small and miserable institutes and the meagre resources with which Baer in Königsberg, Schleiden in Jena, Johannes Müller in Berlin, Liebig in Giessen, Virchow in Würzburg, Gegenbaur in Jena, have not only each advanced his special science most extensively, but have actually created new spheres for them. Compare with these the colossal expenditure and the luxurious apparatus in the grand institutes of Cambridge, Leipsic, and other so-called great universities. What have they produced in proportion to their means?"—*Pall Mall Gazette.*

Maturity of Timber-Trees.—A paper in the "Transactions of the Scottish Arboricultural Society" contains the following information with regard to the time required for various kinds of timber-trees to reach maturity: "The oak can never be cut down so profitably when small as when well matured, and having plenty of heart-wood. The timber is seldom of much value until it has reached the age of 100 years. Ash can be cut down more profitably in its young state than other hard-wood trees. When clean grown, and from thirty to forty years of age, it is in great demand for handle-wood and for agricultural implements. Beech is of very little value in its young state, and is seldom cut till well grown. Birch can be cut down profitably at about forty years old. Horse-chestnut, when grown on good soil, and in a sheltered position, can be profitably cut down when it attains large dimensions. Elms (Scotch and English) should never be cut until they are from eighty to one hundred years old. Poplars can generally be profitably sold when about fifty years old. Sycamore, growing in good soil, may be profitably cut down when about one hundred years old."

Source of the Nitrogen used by Plants.—The average life of an apple-tree in Normandy is estimated by M. Isidore Pierre at fifty years, and its nitrogen product (in leaves, fruit, wood, and roots) at 26 kilogrammes (about 60 pounds). This amount of nitrogen corresponds to 5,200 kilogrammes of farm manure, or 100 kilogrammes per year. But the tree is far from receiving any such amount; according to the author, the most liberal cultivator does not supply more nitrogen than is found in the seeds. The question then arises, Whence comes the remainder of this nitrogen? M. Thenard, in a communication to the Paris Academy of Sciences, denies that it comes directly from the soil, or from the manure, and holds that it is derived from the air *through* the soil. In confirmation of this, he cites the grape-vines of Clos-Vougeot, the youngest of which were planted in 1234, and which annually receive only one kilogramme of manure. The amount of nitrogen contained in this quantity of manure is inconsiderable, as compared with what is contained in the grapes, the leaves, and the wood.

Cranial Measurements.—Two noteworthy results of the comparative measurements of the crania belonging to historic and prehistoric times were dwelt upon by Prof. Rolleston, in his presidential address to the Section of Anthropology, at the last meeting of the British Association. It might be assumed that skulls from the earliest sepulchres would present the smallest capacity, and that the size of the brain-case has since increased with the intellectual development of our race. But this assumption is curiously contradicted by the facts. Indeed, the cubic contents of many skulls from the oldest known interments considerably exceed the capacity of modern European skulls of average build. Surprise at such a result may, however, be tempered by the reflection that the skulls which we have obtained from the earliest tumuli are probably those of the chiefs of their tribes, who may have been selected by virtue of their great energy. Nor should it be forgotten that in savage communities the chiefs come in for a larger share of food, and are, consequently, men of well-developed frames, and of more portly presence than their fellows. As to the poorer specimens of humanity in those days we probably know nothing, as they were denied burial in the tumuli, and have left their remains we know not where. Another curious fact is, that the female skulls from the earliest sepultures do not differ in capacity from the contemporary male skulls to the same degree as the crania of the two sexes differ at the present day. But it must be borne in mind that in those early times there was a greater struggle for existence, and that the division of labor was not carried out to a large extent, so that the tendency to a differentiation of the crania was less marked than in modern times.

An Indian Mill.—On the farm of Mr. Hollis Smith, near Marengo, Calhoun County, Michigan, there exists an interesting monument of aboriginal life, known in the locality as "The Indian Mill." As described in a letter to us by Mr. W. H. Payne, of

Adrian, it consists of a great block of freestone, about fifteen feet in length and five feet in width. Near one edge of this block there is a hole fifteen inches deep, having a diameter at the top of twenty inches, resembling a large mortar. "At the time of my visit," writes Mr. Payne, "this 'mill' was filled with water from recent rains. This was measured as it was dipped out, and amounted to fourteen gallons. Early settlers report that this spot was frequented by Indians, who brought thither their corn to be ground or pounded in this stone mortar. In the vicinity are seen many broad, smooth-faced stones, whose surfaces seem to have been highly heated. It is not improbable that these were used by Indians whereon to bake their cakes of corn. The grain was pounded as follows: A spring-pole was attached to one of the trees which stood near, and from the free end of this was suspended over the mortar, by means of twisted bark, a stone of convenient form and size. Stones suitable for this purpose lie beside the 'mill,' and it is probable that they once served the purpose above indicated."

Excommunicated Insects.—*À propos* of the efforts in progress to destroy the phylloxera and other insect scourges in France, a writer in *La Nature* gives a curious bit of information relative to the way in which such pests used to be proceeded against when science, save so far as it could be made to agree with Romish dogmas, had no existence for the world. In 1120, the Bishop of Laon formally excommunicated all the caterpillars and field-mice. In 1488, the grand-vicars of Autun commanded the parish priests of the vicinity to enjoin the weevils to cease their ravages, and to excommunicate them. In 1585, the grand-vicar of Valence cited the caterpillars to appear before him for trial. He kindly assigned them counsel for their defense, and, as they did not appear, proceeded against and sentenced them, *in contumaciam*, to clear out of his diocese—a command which they probably obeyed!

During the seventeenth century, thirty-seven similar judgments, against both insects and quadrupeds, were issued. One is on record, during the eighteenth century, fulminated against a cow; and there is still another, of later date, due to a judge of Falaise, who condemned and hanged a sow for killing a child.—*Christian Intelligencer.*

Putting out Fires at Sea.—Liquid carbonic acid is proposed by Lieutenant F. M. Barber, U. S. Navy, as an agent for extinguishing fires on board ship. His plan, as communicated to the *American Chemist*, is to have, in some suitable place in the ship, a flask or flasks about three feet in length, and one foot in diameter, containing about 100 pounds of the gas in the liquid state. From the top of the flask, a small iron pipe is to be permanently fitted along the water-ways throughout the entire length of the ship. From this main pipe branch pipes pass to every storeroom and compartment, each branch to be controlled separately by means of a cock. On the alarm of fire, the hatches are to be battened down, the cock in the branch pipe leading to the compartment where the fire is discovered is to be opened, and also the cock in the main next the gas-flask. The liquid gas passes out through the pipe in the form of vapor as soon as the pressure is removed, and is driven to the apartment where the fire is. This compartment it fills from the bottom up, without being diluted with the air. Given the cubic contents of any compartment, and the cubic space occupied by the cargo in it, sufficient gas can be admitted so as to render it absolutely certain that no fire can exist there. By then shutting the cock in the main pipe, the remainder of the gas is kept from vaporizing until such time as it may be required. This method of extinguishing fires is absolutely effectual; furthermore, it is simple, and involves no great expense. The only difficulties which seem to stand in the way of its practical application, are—1. The want of an apparatus for the expeditious and economical production of the liquid gas; and, 2. The want of suitable vessels to hold it at all temperatures. These difficulties, however, have been removed, and hence there exists no reason why all ships should not be provided with this effectual means of preventing disaster by fire.

In England, an apparatus for extinguishing fires on shipboard was recently patented. This apparatus, the "pyroletor," as it is called, consists of a small double pump worked by hand, which sucks up through a tube on each side of it strong muriatic acid, and a solution of bicarbonate of soda; these commingle in a generator forming part of the pump, and the carbonic-acid gas and bicarbonate solution pass at once down a metal pipe to the hold, along whose keelson runs a perforated wooden box which admits of the gas passing through to the burning material. The agent, therefore, for the extinction of fire, is dry carbonic-acid gas, which has no action on the cargo. The *Chemical News* describes as follows an exhibition lately given of the working of the "pyroletor:" "The entire hold of a large wooden barge was covered to a depth of several feet with wood-shavings and cotton-waste saturated with turpentine and naphtha. A temporarily-raised and by no means air-tight wooden deck, with loosely-fitting boards, formed the wide hatchway-covering. The combustible material having been set on fire, the flames immediately ran along the entire cargo and issued above the temporary deck, which was then covered with boarding. The 'pyroletor' having been brought into action, the fire was completely extinguished in four minutes, though nearly half a gale was blowing." It is computed that a 1,200 ton ship requires half a ton of each of the chemicals, costing about $100.

Physical Characters of the British.—Dr. Beddoe, at the recent meeting of the British Association, advocated the necessity, from a practical point of view, not from that of mere scientific curiosity, of obtaining more extensive and accurate information as to the physical characters of man in Britain than could be obtained by private investigations. He desired to inquire thoroughly and systematically into the rates of growth, average stature, weight, etc., of men and women under normal or abnormal conditions, so as to have a fair starting-point for further investigation and action. Lord Aberdare said that some time since it was ascertained that the Irishman was superior to the Scotchman in vigor, and that the Englishman was lowest of the three. This he attributed to the fact that in Ireland and Scotland children were fed on food appropriate to them. He moved that a committee be appointed to collect observations on the subject of the heights and weight of human beings in Great Britain and Ireland, and that a grant of money be made to defray the expenses of such an inquiry. This resolution was adopted.

Native Home of the Rocky Mountain Locust.—In view of the great interest and alarm excited by the ravages of the grasshoppers in the West last year, Prof. C. V. Riley, State Entomologist of Missouri, gives, in the last seventy-five pages of his Seventh Annual Report, a very full and interesting account of the natural history of this insect, including the plants it feeds on, the parasites that feed on it, and a history of its noted incursions, with the means that may profitably be employed to arrest its depredations. From the section on its "native home" we quote some interesting remarks concerning the *spread* of the insect.

Having in July, 1874, given the opinion that the swarms of that year would reach the western counties of Missouri too late to do serious damage, and that they would not extend eastward beyond a line drawn, at a rough estimate, along longitude 17° west from Washington—an opinion, by-the-way, that was remarkably confirmed by subsequent events—the professor here proceeds to give his reasons for that conclusion:

'But it will be asked, 'Upon what do you base this conclusion, and what security have we that at some future time the country east of the line you have indicated may not be ravaged by these plagues from the mountains?' I answer that, during the whole history of the species, as I have attempted to trace it in the chronological account already given, the insect never has done any damage east of the line indicated, and there is no reason to suppose that it ever will do so for the future. . . .

"'But why,' it will again be asked, 'will not the young from the eggs laid along the eastern limit you have indicated hatch and spread farther to the eastward?' Here, again, historical record serves us, and there are, in addition, certain physical facts which help to answer the question.

"There is some difference of opinion as to the precise natural habitat and breeding-place of these insects, but the facts all indicate that it is by nature a denizen of great altitudes, breeding in the valleys, parks, and plateaus of the Rocky Mountain region of Colorado, and especially of Montana, Wyoming, and British America. Prof. Cyrus Thomas, who has had an excellent opportunity of studying it—through his connection with Hayden's geological survey of the Territories—reports it as occurring from Texas to British America, and from the Mississippi (more correctly speaking, the line I have indicated) westward to the Sierra Nevada range. But in all this vast extent of country, and especially in the more southern latitudes, there is every reason to believe that it breeds only on the higher mountain elevations, where the atmosphere is very dry and attenuated, and the soil seldom, if ever, gets soaked with moisture. . . .

"My own belief is, that the insect is at home in the greater altitudes of Utah, Idaho, Colorado, Wyoming, Montana, Northwest Dakota, and British America. It breeds in all this region, but particularly on the vast hot and dry plains and plateaus of the last-named Territories, and on the plains west of the mountains; its range being bounded, perhaps, on the east by that of the buffalo-grass.

"In all this immense stretch of country, as is well known, there are vast tracts of barren, almost desert land, while other tracts, for hundreds of miles, bear only a scanty vegetation, the short buffalo-grass of the more fertile prairies giving way, now to a more luxurious vegetation along the water-courses, now to the sage-bush and a few cacti. Another physical peculiarity is found in the fact that while the spring on these immense plains often opens as early, even away up into British America, as it does with us in the latitude of St. Louis, yet the vegetation is often dried and actually burned out before the first of July, so that not a green thing is to be found. Our Rocky Mountain locust, therefore, hatching out in untold myriads in the hot sandy plains, five or six thousand feet above the sea-level, will often perish in immense numbers if the scant vegetation of its native home dries up before it acquires wings; but if the season is propitious, and the insect becomes fledged before its food-supply is exhausted, the newly-acquired wings prove its salvation. . . . Prompted by that most exigent law of hunger—spurred on for very life—it rises in immense clouds in the air to seek for fresh pastures where it may stay its ravenous appetite. Borne along by the prevailing winds that sweep over these immense treeless plains from the northwest, often at the rate of fifty or sixty miles an hour, the darkening locust-clouds are soon carried into the more moist and fertile country to the southeast, where, with sharpened appetites, they fall upon the crops like a plague and a blight. . . . The hotter and drier the season, and the greater the extent of the drought, the earlier will they be prompted to migrate, and the farther will they push on to the east and south.

"The comparatively sudden change from the attenuated and dry atmosphere of five to eight thousand feet or more above the sea-level to the more humid and dense atmosphere of one thousand feet above that level, does not agree with them. The first generation hatched in this low country is unhealthy, and the few that attain maturity do not breed, but become intestate and 'go to the dogs.' At least, such is the case in our own State, and in the whole of the Mississippi Valley proper. . . ."

Temperature and Vegetation in Different Latitudes.—A communication on this subject was made by M. Alphonse de Candolle to the Academy of Sciences of Paris, and reported in the *Comptes Rendus* for June 7th. The object of the inquiry was to test the accuracy of the very common observation that vegetation comes forward much more rapidly in spring in northern latitudes than in the warmer regions of the temperate zone. Experimenting with seeds of several species of plants sent to him from Northern and Southern Europe, he found that those from the north were most precocious. Twigs, obtained in the winter, of the white poplar, tulip-tree, catalpa, and the *Carpinus betulus*, from Montpellier, were there tried with twigs from the same species at Geneva. They were laid aside, so that their temperature might become alike, and were then placed in water, a little sand being put in the bottom of the jar.

The German, or more northern branches, leafed out first; the difference of time between the leafing of the respective pairs being from eighteen to twenty-three days.

It is an interesting question, "Why do northern plants develop more rapidly than southern ones?" Prof. de Candolle comments on it in this wise: "The buds of a tree are in a continual struggle. The later, like badly-placed ones, develop imperfect branches which are oftener stifled. The most precocious prevail, unless indeed they suffer from frost. In this way comes a selection, and a successive adaptation of the tree to the climate."

Buds, by this means, acquire peculiarities which are persistent. If there be promptness and quickness of growth, these qualities are continually reproduced. An instance of the persistency of acquired peculiarities is given in a horse-chestnut tree near Geneva, which, on a single branch, produced double flowers about the year 1822, and has continued to do so; and all the doubled-flowered horse-chestnuts in the world are thought to be derived from that stock.

De Candolle, however, speaks of the more profound hibernal repose of northern plants producing in the buds greater susceptibility to the heat of spring. But, Prof. Gray, commenting on this in the *American Journal of Science* for September, suggestively remarks that "the way in which this increased susceptibility arises is not stated," and adds, "that natural selection would operate upon trees as upon cereal grains, inducing precocious races better adapted to the short summers, only more time would be required in case of the tree."

Influence of Water on Climate.—At the late meeting of the British Association, Prof. Hennessy read a paper on the "Influence of the Physical Properties of Water on Climate." The object of the paper was to contradict the opinion formerly expressed by Sir J. Herschel, that "water does not distribute heat in any thing like the same degree as land." According to Prof. Hennessy, of all substances largely existing in Nature, water is the most favorable to the absorption and distribution of solar heat. A sandy soil, such as that of the Sahara, although capable of exhibiting a very high temperature during the day, becomes cool during the night, and is one of the worst media for storing up the heat derived from sunshine. Water, on the contrary, stores up heat better than almost any other body. An objection was offered by Prof. Everett, based on the generally-accepted fact that the temperature of the Southern Hemisphere is lower than that of the northern, despite the greater predominance of water in the former. This Prof. Hennessy denied to be a fact.

Curious Behavior of a Snake.—For the following account of an interesting exhibition of serpent-cunning, we are indebted to Mr. E. Lewis, of Brooklyn: "On the 20th of June last, while visiting at the house of a relative on Long Island, I saw on his lawn an adder, a species of snake common in that region. It seemed gentle, and, when approached, made no effort to escape. Wishing to observe its motions, I touched it with a stick, when, instead of moving away, it commenced a series of contortions that greatly surprised me. Nothing that I had seen in the motion of serpents of any kind showed so clearly as did this instance the extraordinary flexibility of their vertebral column. The contortions ended by the creature thrusting its head and open mouth into the loose dirt on the surface as if in great distress, when, partially extending itself and turning on its back, it lay as if quite dead. I lifted it on the stick, and carried it some yards, and laid it on the grass, but observed, in laying it down, that it showed some rigidity, in its tendency to turn or lie on its back. Others, who had witnessed the action of the snake, now left, and I stepped behind a tree for further observation.

"In two or three minutes the head of the snake rose a little, and I could see that it was observing the situation. Presently it turned on its belly, and was in a position to move away; but, on being touched, it turned on its back again. Finally, it raised its head, turned over, and, seeing no one, crawled slowly away.

"This behavior in the snake was new to me, and has not been observed by any with whom I have conversed concerning it. It seems to me probable that it arose from the instinct of self-preservation, or from the equally strong instinct for preservation of its young. No young ones were seen, however, but they may have been near in the grass, and it was a season of the year when their presence might be expected. There was certainly nothing more curious or strange in the snake's feigning death than in birds feigning lameness, and other animals feigning death, when themselves or their young are in danger; but I conclude the phenomenon is unusual with serpents."

A New Enemy of Submarine Cables.—In 1865 the world-renowned special correspondent of the London *Times*, W. H. Russell, modestly gave utterance to a prophecy which time has since fulfilled almost to the letter. He then wrote: "As a mite would in all probability never have been seen but for the invention of cheese, so it may be that there is some undeveloped creation waiting *perdu* for the first piece of gutta-percha, which comes down (to the sea-bottom) to arouse his faculty and fulfill his functions of life—a gutta-percha boring and eating *teredo*, who has been waiting for his meal since the beginning of the world." This enemy of submarine cables has already made his appearance, as was briefly announced in a recent number of The Monthly. It is a crustacean, less than a quarter of an inch in length, and known as *Limnoria terebrans*. "One breakfast which he may take," says Dr. J. H. Gladstone, "may cost more than the breakfast of any luxurious Roman epicure in ancient times, because he may destroy a whole cable, and it may take a year to repair the damage which he may do in a minute."

Hawkshaw on the Channel Tunnel.—In the course of the debate which followed the reading of a paper on the proposed tunnel between England and France, at the Bristol meeting of the British Association, Sir John Hawkshaw made a speech, in which he expressed his perfect confidence in the ultimate success of that great undertaking. "The question arises," said he, "as to the risk in tunneling through the chalk. Of course we cannot measure that risk with any certainty, but we are constantly in the habit of undertaking engineering work which sometimes involves an unknown amount of risk, and it becomes the business of the engineer to encounter these risks. Prof. Hébert seems to expect that the chalk, although it may be continuous, as we have ascertained it to be, all across the channel, may have such fissures in it that, in constructing the tunnel at the depth we propose to go, it is possible we may cut through the chalk into the green sand. Suppose that were so, it would not deter me from encountering this work. A great mistake is often made with reference to the percolation of water. Water, though it passes through sand, passes with very slow velocity. I have had to make deep excavations in sand fifty or sixty feet below the level of the sea, and though water comes rather rapidly at first, until it has drawn away a portion of the water which is in the sand adjacent to your work, yet, after that, it comes with extreme slowness. Therefore, I am not afraid of percolation of water in that sense. With regard to the percolation of water through the solid chalk, that is of no consequence; water passes so slowly through chalk, that it might continue to pass, and nobody would care about it. Of course there is a thing that might occur which would be serious. If you could imagine a clear, open fissure from the bottom of the sea to the tunnel, where water could pass, there is no doubt, with that enormous pressure, it would pass with very great velocity, and would be a very troublesome thing to encounter. I do not myself believe in there being any such fissure. That is almost the only difficulty which, I think, would hinder this tunnel. I do not mean to say that would stop it, but it is possible, if we met with a thing like that, we should have to have recourse to something else, which I have not yet devised, because I do not expect it."

Sanitary Condition of Watering-Places.—At the Baltimore meeting of the American Public Health Association, Prof. Henry Hartshorne read a report on the sanitary condition of our popular watering-places. The report points out the danger to health at such resorts from the contamination of drinking-water by soil saturated with sewage. To prevent this, one or both of two measures must be adopted, namely—1. To use for cooking and drinking either rain-water or water conveyed from a distant, uncontaminated source; or, 2. To protect the soil from contamination by the construction of impervious wells for receiving all impure matters. The former of these measures is always safest; for the latter to be carried out without injury to health requires close and constant supervision. The report finally expresses a desire that records of disease and mortuary statistics of the watering-places in the United States be collected at some central point

Geology at the Syracuse University.—The elementary instruction in geology at Syracuse University, which heretofore has been distributed through the first and second terms of the collegiate year, will be given this year during February and March, so as to occupy the attention of the students with this subject almost exclusively during those two months. The plan is intended to accommodate the large number of persons of all ages who feel the desirableness of an outline acquaintance with geology, and who might be able to devote two months to the study, while their convenience does not permit them to take an entire geological course, or to keep the study in hand six months or a year. Simultaneously with the elementary course, two advanced courses will be set on foot during the months named; one of these courses will be Lithological, and the other Paleontological. Prof. Alexander Winchell will have the general direction of this special school of geology, with numerous assistants, among whom are Prof. James Hall, Prof. Burt G. Wilder, and Prof. Edward D. Cope. The school opens on Tuesday, January 25th.

The Value of Vivisection.—The question of vivisection was the subject of an address by Dr. William Rutherford, at the last meeting of the British Medical Association. Physiology, he observed, is an experimental science. Apart from experiments which are the result of artifice, disease and accident are constantly bringing about conditions which partake of the nature of experiments, and are sometimes of great physiological significance. Still, this teaching of disease and accident leads us but a short way, and the pursuit of physiological truth by their aid is often an uncertain, devious, and complicated method. Dr. Rutherford effectively contrasted the very imperfect and indirect theoretical method of physiological instruction in the past with that by demonstration and experiment in the present time. No one can doubt for a moment that the reasoning, critical faculties are truly educated where men are trained to see and examine for themselves the experimental evidence on which physiological knowledge rests. Dr. Rutherford holds that definite, critical knowledge of animal mechanism cannot be attained unless students be shown experiments on living animals.

Prolific Peaches.—At a meeting of the Academy of Natural Sciences of Philadelphia, Mr. Meehan exhibited some branches of peach, in which the young fruit were in twos and threes from one flower. They were from the Chinese double-flowering kind. He remarked that, as is well known, plants with double flowers are rarely fertile. Either the stamens are wholly changed to petals, or the less vital conditions which always accompany this floral state are unequal to the task of producing perfect pistils. Vitality, however, he observed, is more or less affected by external conditions, independently of the mere structure of organs, and this was well illustrated by the remarkable fertility of the peach last season. This abounding vitality had evidently extended to the double peaches, and had influenced the development of the female organs to an unusual extent. These facts have an interest in botanical classification. Lindley removed the cherry, plum, peach, and their allies from the *Rosaceæ*, chiefly because they had but a single free carpel, and grouped them as *Drupaceæ*. The production of two and three carpels in this case shows the true relation, and it might be of use to those interested in "theories of descent."

Stability of Chinese Civilization.—In accounting for the wonderful cohesion of the great Chinese Empire, the Prussian traveler Von Richthofen says that the causes of this phenomenon are manifold. First, the pitiless extermination of such tribes as the Man-tse. Then the complete fusion of uncultured races with the civilized Chinese, from which has resulted an homogeneous people, with one language, the same manners, and the same traditions. But above all stands the fact that Chinese civilization is indigenous. In Europe, civilization is the result of the efforts of several nations, and has been attained only at the cost of much strife and sacrifice, one people transmitting to another its hard-earned advantages. But in China civilization was developed in more orderly fashion, and is the product of the genius of a single people. The Chinese have very rarely come in contact with neighboring peoples, nor have they borrowed from the Hindoos any thing save Buddhism, and that has certainly been of no advantage to the nation. For 4,000 years they have faithfully preserved the religious and political principles set forth in the decrees of the Emperor Yan, and, though again and again the edifice raised upon this firm foundation has tottered, it has been again set up on the same basis. These principles, which alone uphold the unity of this vast empire, stand to this day intact, nor does Von Richthofen perceive any evidences of senile weakness in the body politic; on the contrary, he thinks that in the future Chinese civilization will have a mighty development, without losing any of its native characteristics. The principles which governed its first establishment, and which are still influential in moulding it, are in fact perfectly in accordance with natural laws, being simply the application to the social and political state of the principles of the paternal authority and filial obedience. In China the authority of the father of a family is unlimited, the obedience of the son is absolute. The emperor, as the father of his subjects, the mandarins, his representatives, receive from the people a filial obedience, but at the same time the sovereign must conform himself to the holy maxims of Confucius. There may be cases of defection, rebellion; functionaries may yield to corruption, as has been the case of late years; but sooner or later order will be restored, and the mandates of the central power will be again respected to the outermost limits of the empire.

European Life in India.—The "Value of European Life in India" was the subject of a paper read at the last meeting of the British Association by Dr. F. J. Mouat. The author stated that within the present century the annual loss of European life in India had gradually and steadily decreased from about 60 per 1,000 to an average of 15 or 16. This decrement is still in progress. Among 24,500 British army officers in India, from 1861 to 1870, the death-rate from all causes was not quite 17 per 1,000. In the Madras Presidency, in the same period, among corresponding classes, the average rate was somewhat less; and, among carefully-selected European railway employés, the parliamentary returns show the mortality rate to be about 10 per 1,000. The author expressed the opinion that the Anglo-Saxon colonization of the plains of India is impossible; but that in the hill country a healthy, vigorous, European population could take root and flourish. On the whole, he regarded the present state of the question as most encouraging, and that the risks to life in India of persons who were sound in constitution, and reasonably prudent in their mode of life, are not much in excess of those incurred in more temperate climates.

Cost of a Small-Pox Epidemic.—At the recent meeting of the American Health Association a paper was read by Dr. Benjamin Lee, on the cost to the city of Philadelphia of the small-pox epidemic which existed there in the winter of 1871–'72. When the disease first appeared, no effective measures were taken to combat it. The public treasury could not bear the expense, it was said; besides, were any thoroughgoing action to be taken by the city authorities, traders from abroad would learn that the disease prevailed in the city, and would go to other markets. Dr. Lee's paper is intended to show that herein the authorities were "penny wise, pound foolish." The direct and the indirect losses caused to Philadelphia by that one visitation of small-pox amount to an enormous sum of money, a small fraction of which would have sufficed, if judiciously expended, to insure immunity from the disease. The losses as computed by Dr. Lee exceed $20,000,000.

NOTES.

The article on "the Horseshoe Nebula in Sagittarius" in the number of The Popular Science Monthly for January, 1876, contains two annoying errors which the editor desires to correct. In Fig. 2, page 271, the letters *W* and *E* and also the letters *N* and *S* are interchanged.

In Fig. 6, page 279, great injustice is done to M. Trouvelot's drawing, owing to the introduction by the engraver of two bright patches near *e* and *d*, and *c* and *h* (*see* figure). These should be as faint as the nebulosity near *g*.

The cores of a pair of enormous ox-horns were discovered, some years since, in Adams County, Ohio, at the depth of about 18 feet below the surface of the ground. According to the *American Journal of Science* they measure nearly 6 feet from tip to tip, and are 22 inches in circumference. The original horns must have been of enormous size, as the core of the horns of the ox is about one-third of the entire length.

These horns are now in the Museum of the Cincinnati Society of Natural History.

It is an error to suppose that the lion is stronger than the tiger. Dr. Haughton has proved that the strength of the lion in the fore-limbs is only 69.9 per cent. of that of the tiger, and the strength of his hind-limbs only 65.9 per cent. Five men can easily hold down a lion, but it requires nine men to control a tiger.

In the course of his researches into the habits of insects, it was found by Lubbock that an ant, which has a large number of larvæ to carry from one place to another, goes and fetches several other ants to aid in the work, while, if there are only a small number of larvæ, only a few helpers are called in.

It is stated by Dr. George Maclean, of Princeton, in a communication to the editors of the *American Journal of Science*, that on one occasion, after some experiments with phosphuretted hydrogen, prepared from phosphorus and solution of potash, on retiring to bed, he found his body to be luminous with a glow like that of phosphorus exposed to the air. Some of the gas, escaping combustion, or the product of its burning, must have been absorbed into the system, and the phosphorus afterward separated at the surface have there undergone eremacausis.

Three instances of extraordinarily rapid growth of plants are recorded in the *Gardener's Chronicle*. First, a *Sequoia gigantea*, planted in 1855, in Loire-Inférieure, France, is now more than 72 feet high, and, about a yard from the ground, has a girth of 7 feet. In the same locality, a plant of *Bambusa mitis* threw up a stem of more than 22 feet in two months, while a *Yucca albospica* produced an inflorescence 8 feet high.

According to Dumas there are two distinct kinds of ferments: those which, like yeast, are capable of self-reproduction, and those which, like diastase and synaptase, are without this property. It has been observed by Muntz that ferments of the former class are neutralized by chloroform; not so those of the latter class.

Prof. S. P. Sharples, of Boston, has drawn up tables showing the range of difference between different specimens of pure milk as regards the amount of solid matter they contain. The highest percentage of solid matter is 19.68, the lowest 9.3.

It is stated in a French journal, *Le Charbon*, that experiments made at Bordeaux with cork, as a substance for developing illuminating gas, have led to such good results that it is proposed to establish a cork gas-house in that city. The waste of cork-cutting shops is distilled in close vessels, and the flame of the resulting gas is more intense and whiter than that of coal-gas. The blue portion of this flame is much less, and the density of the gas much greater than that of common illuminating gas.

It is stated by Galton that in England country boys, of fourteen years, average an inch and a quarter more in height, and seven pounds more in weight, than city boys of the same age, as shown by the examination of a large number of boys in country and city schools.

Dr. Robert Barnes, writing in the *Obstetrical Journal*, questions the propriety of admitting women to the practice of medicine. The reason he assigns is, that there exists a natural incompatibility between science and the female brain. The church and the law he considers to be the professions most congenial to the "somewhat arbitrary character of the female intellect." Clergymen and lawyers are, as a rule, the enemies of science, says Dr. Barnes, and in the women they find their most useful allies.

From observations made in Colorado by a member of the Academy of Natural Sciences, of Philadelphia, it would appear that grasshoppers can foresee, and provide, some time in advance, against certain changes in the weather. It happened that, while a party of persons were riding in a carriage, the question of the probability of rain was discussed, when suddenly the grasshoppers, which just before had filled the air, descended like a shower to the ground. In two or three minutes, not a grasshopper could be seen in the air, and very soon rain commenced to fall. Immediately after the rain had ceased, the insects took flight again, but in the course of half an hour, without any particular indication of rain, they suddenly plunged to the earth again. Again the rain began to fall. This process was repeated by the grasshoppers three times in one afternoon, and each descent was followed by rain.

Herr Marno, of Gordon's Nile Expedition, has reported to the Vienna Geographical Society the particulars of a journey made by him for a distance of 150 miles to the southwest of Lado. This brought him to the Makraka territory, the natives of which he says resemble the Niam-Niams, in respect of their diminutive stature, their lighter color, and their general habits.

In view of the recent barbarous exhibition at the Tombs, the *Scientific American* recommends the employment of electricity, as not only sure and instantaneous in its action, but a painless means of killing the criminal.

Dumas sums up as follows the results of numerous experiments made in order to test the efficacy of the sulpho-carbonate of potassium, in destroying the grape-phylloxera: In the first place, the phylloxera is destroyed wherever the solution of the salt or its vapor penetrates. Secondly, the vine itself suffers no injury. Occasionally, a very few living phylloxeræ are seen after treatment; but these come from other neighboring vines which have not been treated with the sulpho-carbonate, or have been hatched from eggs which have in some way been protected from the action of the salt.

Dr. Rudolf von Willemoes-Suhm, naturalist attached to the Challenger expedition, died at sea on the passage from Hawaii to Tahiti, on September 13, 1875, aged twenty-eight years. He was a native of Schleswig-Holstein, and was educated at the Universities of Göttingen and Bonn. He early showed a very strong taste for natural history, and when only a boy published papers on the habits of European birds. After leaving Bonn he was appointed Privat-Docent in Zoölogy in the Munich University. He went to Italy in 1868, making zoölogical observations at Spezzia, and in 1872 visited the Faröe Islands. He then joined the Challenger expedition. He was a man of unusual acquirements and culture.

The biennial prize of 20,000 francs has been awarded by the Institute of France to M. Paul Bert, for his discoveries on the effects of oxygen in the act of respiration. Some of the principal results of Bert's researches have been stated in the pages of the Monthly. According to the eminent physiologist, Claude Bernard, Bert's discoveries are "the most astounding that have been made since the discovery of oxygen by Priestley."

The Royal Society of London has awarded to Mr. Crookes a "Royal Medal," for his various chemical and physical researches, more especially for his discovery of thallium, his investigation of its compounds, and determination of its atomic weight, and for his discovery of the repulsion referable to radiation.

An interesting experiment made by G. Planté, and described by him to the Paris Academy of Sciences, may possibly explain the spiral form of many of the nebulæ. The two copper electrodes of a battery of 15 elements being immersed in water containing one-tenth of sulphuric acid, the pole of a magnet is brought near to the end of the positive electrode. Immediately the cloud of metallic particles, borne away from this electrode by the current, assumes in the liquid a gyratory, spiral motion, resembling in appearance a spiral nebula.

It will be gratifying to our readers to learn that the preliminary operations of the expedition sent under the auspices of the Hydrographic Office, United States Navy, to determine telegraphically the relative longitudes of points in the West Indies, have been so far successful. Captain Green, U. S. N., assisted by the officers of the United States ship Gettysburg, and by Mr. Rock, civil assistant, has so arranged his programme that the two temporary observatories at Havana and Key West are in the same circuit, and that the signals made at either station are recorded *directly*, without the intervention of the observer at the second station, on his chronograph. It is to be presumed that an important element of uncertainty is thus eliminated. All the arrangements for the work are in good order, and Captain Green acknowledges the most cordial assistance from the officials of the Government and of the cable companies.

The production of gum in fruit-trees, M. Prillieux regards as a disease, which he names *gummosis*. The alimentary substances in the interior tissues, instead of promoting the plant's growth, are diverted to the production of gum, and a portion of them accumulates about gummy centres, which seem to act as centres of irritation. The production of gum at the expense of nutritive matter has no limit short of the complete exhaustion of the plant. The best remedy is scarification. To cure the disease, the materials appropriated to forming gum must be restored to their normal destination. Hence, a more powerful attraction for them must be introduced than that of the gummy centres. Now, the wounds of the bark necessitate the production of new tissues, and, under this strong excitation, the reserve matters are employed in the formation of new cells, and cease to be attracted in the wrong direction.

An instrument for the rapid examination of oils and textures by means of electricity has been invented by Prof. Palmieri. The instrument will—1. Show the quality of olive-oil; 2. Distinguish olive-oil from seed-oil; 3. Indicate whether olive-oil has been mixed with seed-oil; 4. Show the quality of seed-oils; 5. It will indicate the presence of cotton-fibres in silk and woolen textures.

It is stated by Dr. Malherbe that sewing-silk is sometimes impregnated with acetate of lead, and that seamstresses are frequently poisoned by introducing such thread into the mouth.

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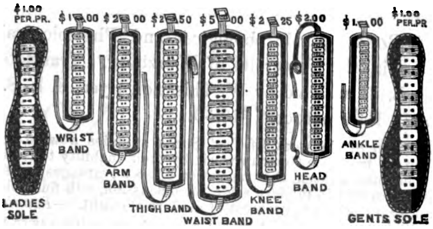

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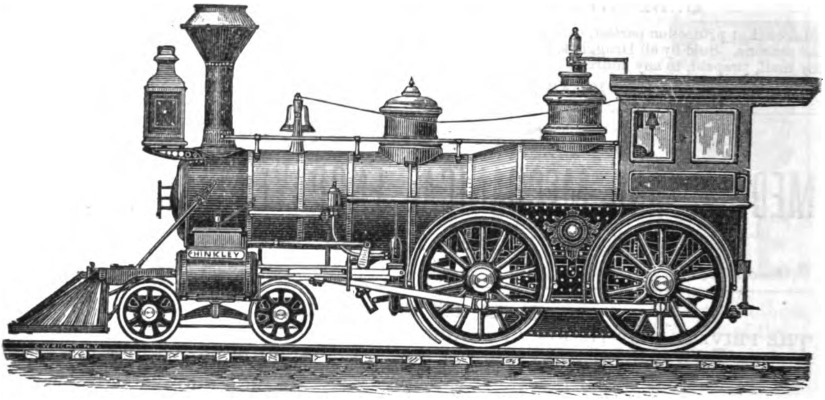

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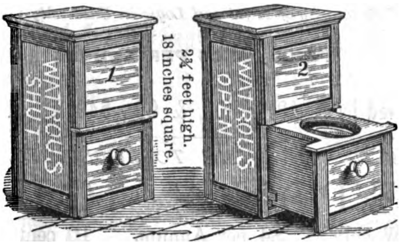

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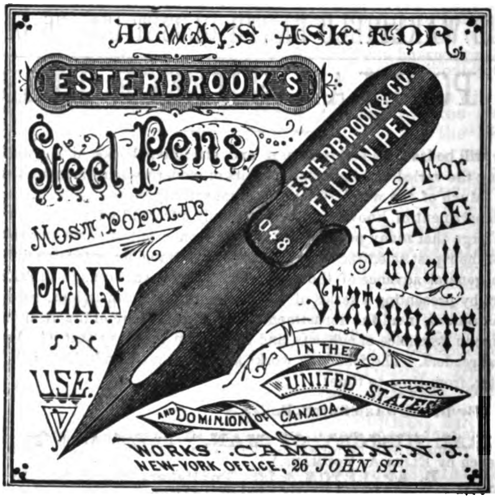

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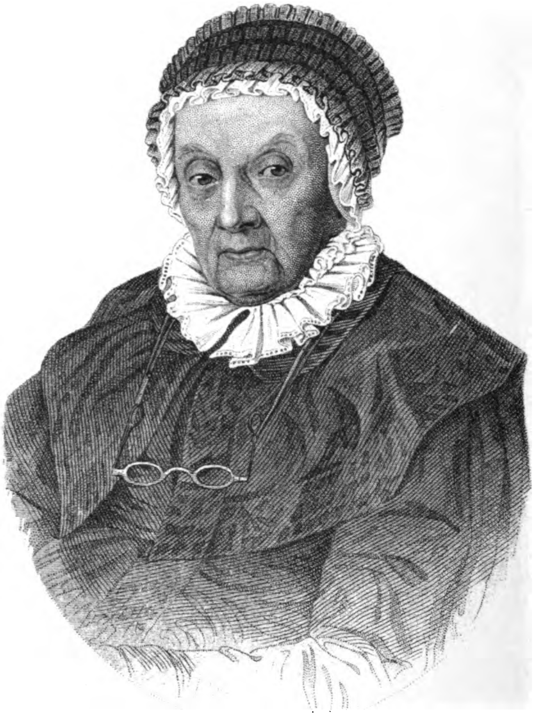

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THE

POPULAR SCIENCE
MONTHLY.

APRIL, 1876.

ON THE BORDER TERRITORY BETWEEN THE ANIMAL AND THE VEGETABLE KINGDOMS.

By T. H. HUXLEY, LL. D., F. R. S.

IN the whole history of science there is nothing more remarkable than the rapidity of the growth of biological knowledge within the last half century, and the extent of the modification which has thereby been effected in some of the fundamental conceptions of the naturalist.

In the second edition of the "Règne Animal," published in 1828, Cuvier devotes a special section to the "Division of Organized Beings into Animals and Vegetables," in which the question is treated with that comprehensiveness of knowledge and clear critical judgment which characterize his writings, and justify us in regarding them as representative expressions of the most extensive, if not the profoundest, knowledge of his time. He tells us that living beings have been subdivided from the earliest time into *animated beings*, which possess sense and motion, and *inanimated beings*, which are devoid of these functions, and simply vegetate.

Although the roots of plants direct themselves toward moisture, and their leaves toward air and light; although the parts of some plants exhibit oscillating movements without any perceptible cause, and the leaves of others retract when touched, yet none of these movements justify the ascription to plants of perception or of will.

From the mobility of animals, Cuvier, with his characteristic partiality for teleological reasoning, deduces the necessity of the existence in them of an alimentary cavity or reservoir of food, whence their nutrition may be drawn by the vessels, which are a sort of internal roots; and in the presence of this alimentary cavity he naturally sees the primary and the most important distinction between animals and plants.

Following out his teleological argument, Cuvier remarks that the organization of this cavity and its appurtenances must needs vary according to the nature of the aliment, and the operations which it has to undergo, before it can be converted into substances fitted for absorption; while the atmosphere and the earth supply plants with juices ready prepared, and which can be absorbed immediately.

As the animal body required to be independent of heat and of the atmosphere, there were no means by which the motion of its fluids could be produced by internal causes. Hence arose the second great distinctive character of animals, or the circulatory system, which is less important than the digestive, since it was unnecessary, and therefore is absent, in the more simple animals.

Animals further needed muscles for locomotion and nerves for sensibility. Hence, says Cuvier, it was necessary that the chemical composition of the animal body should be more complicated than that of the plant; and it is so, inasmuch as an additional substance, nitrogen, enters into it as an essential element, while in plants nitrogen is only accidentally joined with the three other fundamental constituents of organic beings—carbon, hydrogen, and oxygen. Indeed, he afterward affirms that nitrogen is peculiar to animals; and herein he places the third distinction between the animal and the plant.

The soil and the atmosphere supply plants with water, composed of hydrogen and oxygen; air, consisting of nitrogen and oxygen; and carbonic acid, containing carbon and oxygen. They retain the hydrogen and the carbon, exhale the superfluous oxygen, and absorb little or no nitrogen. The essential character of vegetable life is the exhalation of oxygen, which is effected through the agency of light.

Animals, on the contrary, derive their nourishment either directly or indirectly from plants. They get rid of the superfluous hydrogen and carbon, and accumulate nitrogen.

The relations of plants and animals to the atmosphere are therefore inverse. The plant withdraws water and carbonic acid from the atmosphere, the animal contributes both to it. Respiration—that is, the absorption of oxygen, and the exhalation of carbonic acid—is the specially animal function of animals, and constitutes their fourth distinctive character.

Thus wrote Cuvier in 1828. But, in the fourth and fifth decades of this century, the greatest and most rapid revolution which biological science has ever undergone was effected by the application of the modern microscope to the investigation of organic structure; by the introduction of exact and easily manageable methods of conducting the chemical analysis of organic compounds; and, finally, by the employment of instruments of precision for the measurement of the physical forces which are at work in the living economy.

That the semi-fluid contents (which we now term protoplasm) of the cells of certain plants, such as the *Charæ*, are in constant and regular motion, was made out by Bonaventura Corti a century ago; but the fact, important as it was, fell into oblivion, and had to be rediscovered by Treviranus in 1807. Robert Brown noted the most complex motions of the protoplasm in the cells of *Tradescantia* in 1831; and now such movements of the living substance of plants are well known to be some of the most widely-prevalent phenomena of vegetable life.

Agardh, and other of the botanists of Cuvier's generation, who occupied themselves with the lower plants, had observed that, under particular circumstances, the contents of the cells of certain water-weeds were set free and moved about with considerable velocity, and with all the appearances of spontaneity, as locomotive bodies, which, from their similarity to animals of simple organization, were called "zoöspores."

Even as late at 1845, however, a botanist of Schleiden's eminence deals very skeptically with these statements; and his skepticism was the more justified since Ehrenberg, in his elaborate and comprehensive work on the *Infusoria*, had declared the greater number of what are now recognized as locomotive plants to be animals.

At the present day, innumerable plants and free plant-cells are known to pass the whole or part of their lives in an actively locomotive condition, in no wise distinguishable from that of one of the simpler animals; and, while in this condition, their movements are, to all appearance, as spontaneous—as much the product of volition—as those of such animals.

Hence the teleological argument for Cuvier's first diagnostic character—the presence in animals of an alimentary cavity, or internal pocket, in which they can carry about their nutriment, has broken down—so far, at least, as his mode of stating it goes. And, with the advance of microscopic anatomy, the universality of the fact itself among animals has ceased to be predicable. Many animals of even complex structure, which live parasitically within others, are wholly devoid of an alimentary cavity. Their food is provided for them, not only ready cooked, but ready digested, and the alimentary canal, become superfluous, has disappeared. Again, the males of most rotifers have no digestive apparatus; as a German naturalist has remarked, they devote themselves entirely to the "Minnedienst," and are to be reckoned among the few realizations of the Byronic ideal of a lover. Finally, amid the lowest forms of animal life, the speck of gelatinous protoplasm, which constitutes the whole body, has no permanent digestive cavity or mouth, but takes in its food anywhere; and digests, so to speak, all over its body.

But, although Cuvier's leading diagnosis of the animal from the plant will not stand a strict test, it remains one of the most constant of the distinctive characters of animals. And, if we substitute for the possession of an alimentary cavity the power of taking solid nutriment into the body and there digesting it, the definition so changed will cover all animals, except certain parasites, and the few and exceptional cases of non-parasitic animals which do not feed at all. On the other hand, the definition thus amended will exclude all ordinary vegetable organisms.

Cuvier himself practically gives up his second distinctive mark when he admits that it is wanting in the simpler animals.

The third distinction is based on a completely erroneous conception of the chemical differences and resemblances between the constituents of animal and vegetable organisms, for which Cuvier is not responsible, as it was current among contemporary chemists.

It is now established that nitrogen is as essential a constituent of vegetable as of animal living matter; and that the latter is, chemically speaking, just as complicated as the former. Starchy substances, cellulose and sugar, once supposed to be exclusively confined to plants, are now known to be regular and normal products of animals. Amylaceous and saccharine substances are largely manufactured, even by the highest animals; cellulose is widespread as a constituent of the skeletons of the lower animals; and it is probable that amyloid substances are universally present in the animal organism, though not in the precise form of starch.

Moreover, although it remains true that there is an inverse relation between the green plant in sunshine and the animal, in so far as, under these circumstances, the green plant decomposes carbonic acid, and exhales oxygen, while the animal absorbs oxygen and exhales carbonic acid; yet the exact investigations of the modern chemical investigator of the physiological processes of plants have clearly demonstrated the fallacy of attempting to draw any general distinction between animal and vegetable on this ground. In fact, the difference vanishes with the sunshine, even in the case of the green plant; which, in the dark, absorbs oxygen and gives out carbonic acid like any animal. While those plants, such as the fungi, which contain no chlorophyl and are not green, are always, so far as respiration is concerned, in the exact position of animals. They absorb oxygen and give out carbonic acid.

Thus, by the progress of knowledge, Cuvier's fourth distinction between the animal and the plant has been as completely invalidated as the third and second; and even the first can be retained only in a modified form and subject to exceptions.

But has the advance of biology simply tended to break down old distinctions, without establishing new ones?

With a qualification, to be considered presently, the answer to this question is undoubtedly in the affirmative. The famous researches of Schwann and Schleiden, in 1837 and the following years, founded the modern science of histology, or that branch of anatomy which deals with the ultimate visible structure of organisms, as revealed by the microscope; and, from that day to this, the rapid improvement of methods of investigation and the energy of a host of accurate observers have given greater and greater breadth and firmness to Schwann's great generalization, that a fundamental unity of structure obtains in animals and plants; and that, however diverse may be the fabrics, or *tissues*, of which their bodies are composed, all these varied structures result from the metamorphoses of morphological units (termed *cells*, in a more general sense than, that in which the word "cells" was at first employed), which are not only similar in animals and in plants respectively, but present a close fundamental resemblance when those of animals and those of plants are compared together.

The contractility which is the fundamental condition of locomotion has not only been discovered to exist far more widely among plants than was formerly imagined, but, in plants, the act of contraction has been found to be accompanied, as Dr. Burdon Sanderson's interesting investigations have shown, by a disturbance of the electrical state of the contractile substance comparable to that which was found by Du Bois-Reymond to be a concomitant of the activity of ordinary muscle in animals.

Again, I know of no tests by which the reaction of the leaves of the sundew and of other plants to stimuli, so fully and carefully studied by Mr. Darwin, can be distinguished from those acts of contraction following upon stimuli, which are called "reflex" in animals.

On each lobe of the bilobed leaf of Venus's fly-trap (*Dionœa muscipula*) are three delicate filaments which stand out at right angles from the surface of the leaf. Touch one of them with the end of a fine human hair, and the lobes of the leaf instantly close together[1] in virtue of an act of contraction of part of their substance, just as the body of a snail contracts into its shell when one of its "horns" is irritated.

The reflex action of the snail is the result of the presence of a nervous system in that animal. A molecular change takes place in the nerve of the tentacle, is propagated to the muscles by which the body is retracted, and, causing them to contract, the act of retraction is brought about. Of course the similarity of the acts does not necessarily involve the conclusion that the mechanism by which they are effected is the same; but it suggests a suspicion of their identity which needs careful testing.

The results of recent inquiries into the structure of the nervous system of animals converge toward the conclusion that the nerve-fibres, which we have hitherto regarded as ultimate elements of nervous tissue, are not such, but are simply the visible aggregations of vastly more attenuated filaments, the diameter of which dwindles down to the limits of our present microscopic vision, greatly as these have been extended by modern improvements of the microscope; and that a nerve is, in its essence, nothing but a linear tract of specially modified protoplasm between two points of an organism—one of which is able to affect the other by means of the communication so established. Hence it is conceivable that even the simplest living being may possess a nervous system. And the question whether plants are provided with a nervous system or not thus acquires a new aspect, and presents the histologist and physiologist with a problem of extreme difficulty, which must be attacked from a new point of view and by the aid of methods which have yet to be invented.

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[1] Darwin, "Insectivorous Plants," p. 289.

Thus it must be admitted that plants may be contractile and locomotive; that, while locomotive, their movements may have as much appearance of spontaneity as those of the lowest animals; and that many exhibit actions comparable to those which are brought about by the agency of a nervous system in animals. And it must be allowed to be possible that further research may reveal the existence of something comparable to a nervous system in plants. So that I know not where we can hope to find any absolute distinction between animals and plants, unless we return to their mode of nutrition, and inquire whether certain differences of a more occult character than those imagined to exist by Cuvier, and which certainly hold good for the vast majority of animals and plants, are of universal application.

A bean may be supplied with water in which salts of ammonia and certain other mineral salts are dissolved in due proportion; with atmospheric air containing its ordinary minute dose of carbonic acid; and with nothing else but sunlight and heat. Under these circumstances, unnatural as they are, with proper management, the bean will thrust forth its radicle and its plumule; the former will grow down into roots, the latter grow up into the stem and leaves of a vigorous bean-plant; and this plant will, in due time, flower and produce its crops of beans, just as if it were grown in the garden or in the field.

The weight of the nitrogenous proteine compounds of the oily, starchy, saccharine, and woody substances contained in the full-grown plant and its seeds will be vastly greater than the weight of the same substances contained in the bean from which it sprang. But nothing has been supplied to the bean save water, carbonic acid, ammonia, potash, lime, iron, and the like, in combination with phosphoric, sulphuric, and other acids. Neither proteine, nor fat, nor starch, nor sugar, nor any substance in the slightest degree resembling them, has formed part of the food of the bean. But the weights of the carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, and other elementary bodies contained in the bean-plant, and in the seeds which it produces, are exactly equivalent to the weights of the same elements which have disappeared from the materials supplied to the bean during its growth. Whence it follows that the bean has taken in only the raw materials of its fabric and has manufactured them into bean-stuffs.

The bean has been able to perform this great chemical feat by the help of its green coloring matter, or chlorophyl, which, under the influence of sunlight, has the marvelous power of decomposing carbonic acid, setting free the oxygen, and laying hold of the carbon which it contains. In fact, the bean obtains two of the absolutely indispensable elements of its substance from two distinct sources; the watery solution, in which its roots are plunged, contains nitrogen but no carbon; the air, to which the leaves are exposed, contains carbon, but its nitrogen is in the state of a free gas, in which condition the bean can make no use of it;[1] and the chlorophyl is the apparatus by which the carbon is extracted from the atmospheric carbonic acid—the leaves being the chief laboratories in which this operation is effected.

The great majority of conspicuous plants are, as everybody knows, green; and this arises from the abundance of their chlorophyl. The few which contain no chlorophyl and are colorless are unable to extract the carbon which they require from atmospheric carbonic acid, and lead a parasitic existence upon other plants; but it by no means follows, often as the statement has been repeated, that the manufacturing power of plants depends on their chlorophyl and its interaction with the rays of the sun. On the contrary, it is easily demonstrated, as Pasteur first proved, that the lowest fungi, devoid of chlorophyl, or of any substitute for it, as they are, nevertheless possess the characteristic manufacturing powers of plants in a very high degree. Only it is necessary that they should be supplied with a different kind of raw material; as they cannot extract carbon from carbonic acid, they must be furnished with something else that contains carbon. Tartaric acid is such a substance; and if a single spore of the commonest and most troublesome of moulds—*Penicillium*—be sown in a saucer full of water, in which tartrate of ammonia, with a small percentage of phosphates and sulphates is contained, and kept warm, whether in the dark or exposed to light, it will in a short time give rise to a thick crust of mould, which contains many million times the weight of the original spore in proteine compounds and cellulose. Thus we have a very wide basis of fact for the generalization that plants are essentially characterized by their manufacturing capacity, by their power of working up mere mineral matters into complex organic compounds.

Contrariwise, there is no less wide foundation for the generalization that animals, as Cuvier puts it, depend directly or indirectly upon plants for the materials of their bodies; that is, either they are herbivorous, or they eat other animals which are herbivorous.

But for what constituents of their bodies are animals thus dependent upon plants? Certainly not for their horny matter; nor for chondrine, the proximate chemical element of cartilage; nor for gelatine, nor for syntonine, the constituent of muscle; nor for their nervous or biliary substances; nor for their amyloid matters, nor, necessarily, for their fats.

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[1] I purposely assume that the air with which the bean is supplied in the case stated contains no ammoniacal salts.

It can be experimentally demonstrated that animals can make these for themselves. But that which they cannot make, but must in all known cases obtain directly or indirectly from plants, is the peculiar nitrogenous matter proteine. Thus the plant is the ideal *prolétaire* of the living world, the worker who produces; the animal, the ideal aristocrat, who mostly occupies himself in consuming, after the manner of that noble representative of the line of Zähdarm, whose epitaph is written in "Sartor Resartus."

Here is our last hope of finding a sharp line of demarkation between plants and animals; for, as I have already hinted, there is a border-territory between the two kingdoms, a sort of no-man's land, the inhabitants of which certainly cannot be discriminated and brought to their proper allegiance in any other way.

Some months ago, Prof. Tyndall asked me to examine a drop of infusion of hay, placed under an excellent and powerful microscope, and to tell him what I thought some organisms visible in it were. I looked and observed, in the first place, multitudes of *Bacteria* moving about with their ordinary intermittent spasmodic wriggles. As to the vegetable nature of these there is now no doubt. Not only does the close resemblance of the *Bacteria* to unquestionable plants, such as the *Oscillatoriæ*, and lower forms of *Fungi*, justify this conclusion, but the manufacturing test settles the question at once. It is only needful to add a minute drop of fluid containing *Bacteria*, to water in which tartrate, phosphate, and sulphate of ammonia are dissolved, and, in a very short space of time, the clear fluid becomes milky by reason of their prodigious multiplication, which, of course, implies the manufacture of living Bacterium-stuff out of these merely saline matters.

But other active organisms, very much larger than the *Bacteria*, attaining in fact the comparatively gigantic dimensions of $\frac{1}{3000}$ of an inch or more, incessantly crossed the field of view. Each of these had a body shaped like a pear, the small end being slightly incurved and produced into a long curved filament, or *cilium*, of extreme tenuity. Behind this, from the concave side of the incurvation, proceeded another long cilium, so delicate as to be discernible only by the use of the highest powers and careful management of the light. In the centre of the pear-shaped body a clear round space could occasionally be discerned, but not always; and careful watching showed that this clear vacuity appeared gradually, and then shut up and disappeared suddenly, at regular intervals. Such a structure is of common occurrence among the lowest plants and animals, and is known as a *contractile vacuole*.

The little creature thus described sometimes propelled itself with great activity, with a curious rolling motion, by the lashing of the front cilium, while the second cilium trailed behind; sometimes it anchored itself by the hinder cilium and was spun round by the working of the other, its motions resembling those of an anchor-buoy in a heavy sea. Sometimes, when two were in full career toward one another, each would appear dexterously to get out of the other's way; sometimes a crowd would assemble and jostle one another, with as much semblance of individual effort as a spectator on the Grands Mulets might observe with a telescope among the specks representing men in the valley of Chamounix.

The spectacle, though always surprising, was not new to me. So my reply to the question put to me was, that these organisms were what biologists call *Monads*, and though they might be animals, it was also possible that they might, like the *Bacteria*, be plants. My friend received my verdict with an expression which showed a sad want of respect for authority. He would as soon believe that a sheep was a plant. Naturally piqued by this want of faith, I have thought a good deal over the matter; and as I still rest in the lame conclusion I originally expressed, and must even now confess that I cannot certainly say whether this creature is an animal or a plant, I think it may be well to state the grounds of my hesitation at length. But, in the first place, in order that I may conveniently distinguish this "monad" from the multitude of other things which go by the same designation, I must give it a name of its own. I think (though, for reasons which need not be stated at present, I am not quite sure) that it is identical with the species *Monas lens*, as defined by the eminent French microscopist Dujardin, though his magnifying power was probably insufficient to enable him to see that it is curiously like a much larger form of monad which he has named *Heteromita*. I shall, therefore, call it not *Monas*, but *Heteromita lens*.

I have been unable to devote to my *Heteromita* the prolonged study needful to work out its whole history, which would involve weeks, or it may be months, of unremitting attention. But I the less regret this circumstance, as some remarkable observations, recently published by Messrs. Dallinger and Drysdale,[1] on certain monads, relate, in part, to a form so similar to my *Heteromita lens*, that the history of the one may be used to illustrate that of the other. These most patient and painstaking observers, who employed the highest attainable powers of the microscope and, relieving one another, kept watch day and night over the same individual monads, have been enabled to trace out the whole history of their *Heteromita;* which they found in infusions of the heads of fishes of the cod tribe.

Of the four monads described and figured by these investigators, one, as I have said, very closely resembles *Heteromita lens* in every particular, except that it has a separately distinguishable central particle or "nucleus," which is not certainly to be made out in *Heteromita lens;* and that nothing is said by Messrs. Dallinger and Drysdale of the existence of a contractile vacuole in this monad, though they describe it in another.

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[1] "Researches in the Life-history of a Cercomonad: a Lesson in Biogenesis," and "Further Researches in the Life-history of the Monads," *Monthly Microscopical Journal*, 1873.

Their *Heteromita*, however, multiplied rapidly by fission. Sometimes a transverse constriction appeared; the hinder half developed a new cilium, and the hinder cilium gradually split from its base to its free end, until it was divided into two; a process which, considering the fact that this fine filament cannot be much more than $\frac{1}{100000}$ of an inch in diameter, is wonderful enough. The constriction of the body extended inward until the two portions were united by a narrow isthmus; finally they separated, and each swam away by itself, a complete *Heteromita*, provided with its two cilia. Sometimes the constriction took a longitudinal direction, with the same ultimate result. In each case the process occupied not more than six or seven minutes. At this rate, a single *Heteromita* would give rise to a thousand like itself in the course of an hour, to about a million in two hours, and to a number greater than the generally-assumed number of human beings now living in the world in three hours; or, if we give each *Heteromita* an hour's enjoyment of individual existence, the same result will be obtained in about a day. The apparent suddenness of the appearance of multitudes of such organisms as these, in any nutritive fluid to which one obtains access, is thus easily explained.

During these processes of multiplication by fission, the *Heteromita* remains active; but sometimes another mode of fission occurs. The body becomes rounded and quiescent, or nearly so, and, while in this resting state, divides into two portions, each of which is rapidly converted into an active *Heteromita*.

A still more remarkable phenomenon is that kind of multiplication which is preceded by the union of two monads, by a process which is termed *conjugation*. Two active *Heteromitæ* become applied to one another, and then slowly and gradually coalesce into one body. The two nuclei run into one; and the mass resulting from the conjugation of the two *Heteromitæ*, thus fused together, has a triangular form. The two pairs of cilia are to be seen, for some time, at two of the angles, which answer to the small ends of the conjoined monads; but they ultimately vanish, and the twin organism, in which all visible traces of organization have disappeared, falls into a state of rest. Sudden wave-like movements of its substance next occur; and, in a short time, the apices of the triangular mass burst, and give exit to a dense yellowish, glairy fluid filled with minute granules. This process, which, it will be observed, involves the actual confluence and mixture of the substance of two distinct organisms, is effected in the space of about two hours.

The authors whom I quote say that they "cannot express" the excessive minuteness of the granules in question, and they estimate their diameter at less than $\frac{1}{200000}$ of an inch. Under the highest powers of the microscope at present applicable, such specks are hardly discernible. Nevertheless, particles of this size are massive when compared to physical molecules; whence there is no reason to doubt that each, small as it is, may have a molecular structure sufficiently complex to give rise to the phenomena of life. And, as a matter of fact, by patient watching of the place at which these infinitesimal living particles were discharged, our observers assured themselves of their growth and development into new monads. These, in about four hours from their being set free, had attained a sixth of the length of the parent, with the characteristic cilia, though at first they were quite motionless; and in four hours more they had attained the dimensions and exhibited all the activity of the adult. These inconceivably minute particles are therefore the germs of the *Heteromita;* and from the dimensions of these germs it is easily shown that the body formed by conjugation may, at a low estimate, have given exit to 30,000 of them; a result of a matrimonial process whereby the contracting parties, without a metaphor, "become one flesh," enough to make a Malthusian despair of the future of the universe.

I am not aware that the investigators from whom I have borrowed this history have endeavored to ascertain whether their monads take solid nutriment or not; so that, though they help us very much to fill up the blanks in the history of my *Heteromita*, their observations throw no light on the problem we are trying to solve—Is it an animal or is it a plant?

Undoubtedly it is possible to bring forward very strong arguments in favor of regarding *Heteromita* as a plant.

For example, there is a fungus, an obscure and almost microscopic mould, termed *Peronospora infestans.* Like many other fungi, the *Peronosporæ* are parasitic upon other plants; and this particular *Peronospora* happens to have attained much notoriety and political importance, in a way not without a parallel in the career of notorious politicians, namely, by reason of the frightful mischief it has done to mankind. For it is this *Fungus* which is the cause of the potato-disease; and, therefore, *Peronospora infestans* (doubtless of exclusively Saxon origin, though not accurately known to be so) brought about the Irish famine. The plants afflicted with the malady are found to be infested by a mould, consisting of fine tubular filaments, termed *hyphæ*, which burrow through the substance of the potato-plant, and appropriate to themselves the substance of their host; while, at the same time, directly or indirectly, they set up chemical changes by which even its woody framework becomes blackened, sodden, and withered.

In structure, however, the *Peronospora* is as much a mould as the common *Penicillium;* and just as the *Penicillium* multiplies by the breaking up of its hyphæ into separate rounded bodies, the spores, so, in the *Peronospora*, certain of the hyphæ grow out into the air through the interstices of the superficial cells of the potato-plant, and develop spores. Each of these hyphæ usually gives off several branches. The ends of the branches dilate and become closed sacs, which eventually drop off as spores. The spores falling on some part of the same potato-plant, or carried by the wind to another, may at once germinate, throwing out tubular prolongations which become hyphæ, and burrow into the substance of the plant attacked. But, more commonly, the contents of the spore divide into six or eight separate portions. The coat of the spore gives way, and each portion then emerges as an independent organism, which has the shape of a bean, rather narrower at one end than the other, convex on one side, and depressed or concave on the opposite. From the depression, two long and delicate cilia proceed, one shorter than the other, and directed forward. Close to the origin of these cilia, in the substance of the body, is a regularly-pulsating contractile vacuole. The shorter cilium vibrates actively, and effects the locomotion of the organism, while the other trails behind, the whole body rolling on its axis with its pointed end forward.

The eminent botanist, De Bary, who was not thinking of our problem, tells us, in describing the movements of these "zoöspores," that, as they swim about, "foreign bodies are carefully avoided, and the whole movement has a deceptive likeness to the voluntary changes of place which are observed in microscopic animals."

After swarming about in this way in the moisture on the surface of a leaf or stem (which, film though it may be, is an ocean to such a fish) for half an hour, more or less, the movement of the zoöspore becomes slower, and is limited to a slow turning upon its axis, without change of place. It then becomes quite quiet, the cilia disappear, it assumes a spherical form, and surrounds itself with a distinct though delicate membranous coat. A protuberance then grows out from one side of the sphere, and, rapidly increasing in length, assumes the character of a hypha. The latter penetrates into the substance of the potato-plant, either by entering a stomate or by boring through the wall of an epidermic cell, and ramifies, as a mycelium, in the substance of the plant, destroying the tissues with which it comes in contact. As these processes of multiplication take place very rapidly, millions of spores are soon set free from a single infested plant; and from their minuteness they are readily transported by the gentlest breeze. Since, again, the zoöspores set free from each spore, in virtue of their powers of locomotion, swiftly disperse themselves over the surface, it is no wonder that the infection, once started, soon spreads from field to field, and extends its ravages over a whole country.

However, it does not enter into my present plan to treat of the potato-disease, instructively as its history bears upon that of other epidemics; and I have selected the case of the *Peronospora* simply because it affords an example of an organism, which, in one stage of its existence, is truly a "monad," indistinguishable by any important character from our *Heteromita*, and extraordinarily like it in some respects. And yet this "monad" can be traced, step by step, through the series of metamorphoses which I have described, until it assumes the features of an organism, which is as much a plant as an oak or an elm is.

Moreover, it would be possible to pursue the analogy further. Under certain circumstances, a process of conjugation takes place in the *Peronospora*. Two separate portions of its protoplasm become fused together, surround themselves with a thick coat, and give rise to a sort of vegetable egg called an *oöspore*. After a period of rest, the contents of the oöspore break up into a number of zoöspores like those already described, each of which, after a period of activity, germinates in the ordinary way. This process obviously corresponds with the conjugation and subsequent setting free of germs in the *Heteromita*.

But it may be said that the *Peronospora* is, after all, a questionable sort of plant; that it seems to be wanting in the manufacturing power, selected as the main distinctive character of vegetable life; or, at any rate, that there is no proof that it does not get its proteine matter ready made from the potato-plant.

Let us, therefore, take a case which is not open to these objections.

There are some small plants known to botanists as members of the genus *Coleochæte*, which, without being truly parasitic, grow upon certain water-weeds, as lichens grow upon trees. The little plant has the form of an elegant green star, the branching arms of which are divided into cells. Its greenness is due to its chlorophyl, and it undoubtedly has the manufacturing power in full degree, decomposing carbonic acid and setting free oxygen under the influence of sunlight.

But the protoplasmic contents of some of the cells of which the plant is made up occasionally divide, by a method similar to that which effects the division of the contents of the *Peronospora*-spore; and the severed portions are then set free as active monad-like zoöspores. Each is oval and is provided at one extremity with two long active cilia. Propelled by these, it swims about for a longer or shorter time, but at length comes to a state of rest, and gradually grows into a *Coleochæte*.

Moreover, as in the *Peronospora*, conjugation may take place and result in an oöspore; the contents of which divide and are set free as monadiform germs.

If the whole history of the zoöspores of *Peronospora* and *Coleo-*

chæte were unknown, they would undoubtedly be classed among "monads" with the same right as *Heteromita;* why, then, may not *Heteromita* be a plant, even though the cycle of forms through which it passes shows no terms quite so complex as those which occur in *Peronospora* and *Coleochæte?* And, in fact, there are some green organisms, in every respect characteristically plants, such as *Chlamydomonas*, and the common *Volvox*, or so-called "Globe animalcule," which run through a cycle of forms of just the same simple character as those of *Heteromita.*

The name of *Chlamydomonas* is applied to certain microscopic green bodies, each of which consists of a protoplasmic central substance invested by a structureless sac. The latter contains cellulose, as in ordinary plants; and the chlorophyl which gives the green color enables the *Chlamydomonas* to decompose carbonic acid and fix carbon, as they do. Two long cilia protrude through the cell-wall, and effect the rapid locomotion of this "monad," which, in all respects except its mobility, is characteristically a plant.

Under ordinary circumstances the *Chlamydomonas* multiplies by simple fission, each splitting into two or into four parts, which separate and become independent organisms. Sometimes, however, the *Chlamydomonas* divides into eight parts, each of which is provided with four instead of two cilia. These "zoöspores" conjugate in pairs, and give rise to quiescent bodies, which multiply by division, and eventually pass into the active state.

Thus, so far as outward form and the general character of the cycle of modifications through which the organism passes in the course of its life are concerned, the resemblance between *Chlamydomonas* and *Heteromita* is of the closest description. And on the face of the matter there is no ground for refusing to admit that *Heteromita* may be related to *Chlamydomonas*, as the colorless fungus is to the green alga. *Volvox* may be compared to a hollow sphere, the wall of which is made up of coherent Chlamydomonads; and which progresses with a rotating motion effected by the paddling of the multitudinous pairs of cilia which project from its surface. Each *Volvox*-monad has a contractile vacuole like that of *Heteromita lens;* and, moreover, possesses a red pigment-spot like the simplest form of eye known among animals.

The methods of fissive multiplication and of conjugation observed in the monads of this locomotive globe are essentially similar to those observed in *Chlamydomonas;* and, though a hard battle has been fought over it, *Volvox* is now finally surrendered to the botanists.

Thus there is really no reason why *Heteromita* may not be a plant; and this conclusion would be very satisfactory, if it were not equally easy to show that there is really no reason why it should not be an animal.

For there are numerous organisms presenting the closest resemblance to *Heteromita*, and, like it, grouped under the general name of "Monads," which, nevertheless, can be observed to take in solid nutriment, and which therefore have a virtual, if not an actual, mouth and digestive cavity, and thus come under Cuvier's definition of an animal. Numerous forms of such animals have been described by Ehrenberg, Dujardin, H. James Clark, and other writers on the *Infusoria*.

Indeed, in another infusion of hay in which my *Heteromita lens* occurred, there were innumerable infusorial animalcules belonging to the well-known species *Colpoda cucullus*.[1]

Full-sized specimens of this animalcule attain a length of between $\frac{1}{300}$ or $\frac{1}{400}$ of an inch, so that it may have ten times the length and a thousand times the mass of a *Heteromita*. In shape it is not altogether unlike *Heteromita*. The small end, however, is not produced into one long cilium, but the general surface of the body is covered with small, actively-vibrating ciliary organs, which are only longest at the small end. At the point which answers to that from which the two cilia arise in *Heteromita*, there is a conical depression, the mouth; and in young specimens a tapering filament, which reminds one of the posterior cilium of *Heteromita*, projects from this region.

The body consists of a soft granular protoplasmic substance, the middle of which is occupied by a large oval mass called the "nucleus;" while at its hinder end is a "contractile vacuole," conspicuous by its regular rhythmic appearances and disappearances. Obviously, although the *Colpoda* is not a monad, it differs from one only in subordinate details. Moreover, under certain conditions, it becomes quiescent, incloses itself in a delicate case or *cyst*, and then divides into two, four, or more portions, which are eventually set free and swim about as active *Colpodæ*.

But this creature is an unmistakable animal, and full-sized *Colpodæ* may be fed as easily as one feeds chickens. It is only needful to diffuse very finely-ground carmine through the water in which they live, and, in a very short time, the bodies of the *Colpodæ* are stuffed with the deeply-colored granules of the pigment.

And if this were not sufficient evidence of the animality of *Colpoda*, there comes the fact that it is even more similar to another well-known animalcule, *Paramœcium*, than it is to a monad. But *Paramœcium* is so huge a creature compared with those hitherto discussed—it reaches $\frac{1}{120}$ of an inch or more in length—that there is no difficulty in making out its organization in detail; and in proving that it is not only an animal, but that it is an animal which possesses a somewhat complicated organization. For example, the surface-layer of its body is different in structure from the deeper parts. There are two contractile vacuoles, from each of which radiates a system of vessel-like canals; and not only is there a conical depression continuous with a tube, which serve as mouth and gullet, but the food ingested takes a definite course and refuse is rejected from a definite region. Nothing is easier than to feed these animals and to watch the particles of indigo or carmine accumulate at the lower end of the gullet. From this they gradually project, surrounded by a ball of water, which at length passes with a jerk, oddly simulating a gulp, into the pulpy central substance of the body, there to circulate up one side and down the other, until its contents are digested and assimilated. Nevertheless, this complex animal multiplies by division, as the monad does, and, like the monad, undergoes conjugation. It stands in the same relation to *Heteromita* on the animal side, as *Coleochœte* does on the plant side. Start from either, and such an insensible series of gradations leads to the monad that it is impossible to say at any stage of the progress, Here the line between the animal and the plant must be drawn.

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[1] Excellently described by Stein, almost all of whose statements I have verified.

There is reason to think that certain organisms which pass through a monad stage of existence, such as the *Myxomycetes*, are, at one time of their lives, dependent upon external sources for their proteine-matter, or are animals, and at another period manufacture it, or are plants. And, seeing that the whole progress of modern investigation is in favor of the doctrine of continuity, it is a fair and probable speculation—though only a speculation—that, as there are some plants which can manufacture proteine out of such apparently intractable mineral matters as carbonic acid, water, nitrate of ammonia, and metallic salts, while others need to be supplied with their carbon and nitrogen in the somewhat less raw form of tartrate of ammonia and allied compounds, so there may be yet others, as is possibly the case with the true parasitic plants, which can only manage to put together materials still better prepared—still more nearly approximated to proteine—until we arrive at such organisms as the *Psorospermiœ* and the *Panhistophyton*, which are as much animal as vegetable in structure, but are animal in their dependence on other organisms for their food.

The singular circumstance observed by Meyer, that the *Torula* of yeast, though an indubitable plant, still flourishes most vigorously when supplied with the complex nitrogenous substance, pepsin; the probability that the *Peronospora* is nourished directly by the protoplasm of the potato-plant; and the wonderful facts which have recently been brought to light respecting insectivorous plants, all favor this view; and tend to the conclusion that the difference between animal and plant is one of degree rather than of kind; and that the problem, whether, in a given case, an organism is an animal or a plant, may be essentially insoluble.—*Macmillan's Magazine.*

AN INTERESTING BIRD.

By J. H. KIDDER, M. D.,
PASSED ASSISTANT SURGEON, UNITED STATES NAVY.

KERGUELEN Island is in latitude 48°–49° south; longitude 70° east from Greenwich. That is to say, it is in the South Indian Ocean, about half-way between the Cape of Good Hope and Australia, but well to the southward of both. It is rather an archipelago than an island, innumerable small peaks being grouped around and in the estuaries of a central mass of volcanic rock, about ninety miles long by fifty wide, and shaped somewhat like a spider, of which its numerous long promontories and peninsulas represent the legs. Being treeless, barren, uninhabited, and uninhabitable, and situated in a region given over to boisterous gales and continual rain or snow, it is a country seldom visited. It was discovered about a hundred years ago, by the unfortunate Lieutenant Kerguelen, of the French marine, and about two years afterward found again by Captain Cook, who gave it the name of Desolation Island. During May, June, and July, 1840, Sir James Clark Ross remained there with the Erebus and Ter-

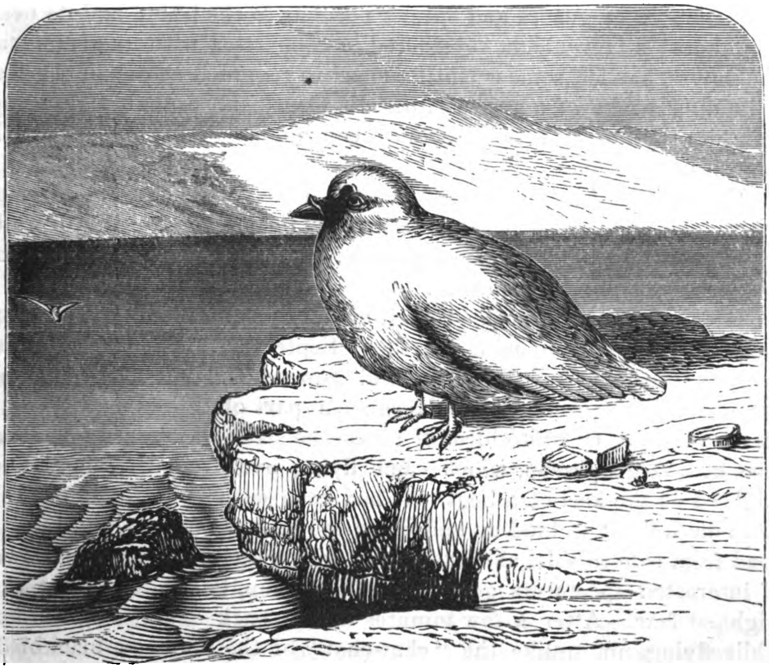

FIG. 1.—THE SHEATH-BILL OF KERGUELEN ISLAND.

ror; and it is to this visit, and to the fact that Dr. Joseph D. Hooker was botanist to the expedition, that we owe our present full knowledge of the botany of the island. Had it not been long noted as a favorite breeding-place for the sea-elephant, and hence resorted to by sealers and whalers, it is doubtful whether any human being, other than the intrepid explorers already alluded to, would have cared to visit so desolate and forbidding a spot, until it came to be fixed upon as a locality whence the transit of Venus could advantageously be observed.

Lying, as this island does, upon the very skirts of the world, far removed from any large body of land, and so placed as to be very unlikely to receive additions to its flora and fauna by the agency of either winds or currents, it was to be expected that its natural history would present very many peculiarities, both of form and of adaptation. Its flora, accordingly, and invertebrate animal life include an unusually large number of genera and species peculiar to the island and its near neighbors; a fact which, considered in connection with its geological characters, has led some scientific men[1] to regard it as one of the few remaining peaks of a great Antarctic Continent, probably (judging from its botanical relations) once continuous with that of South America.

Even among birds there are at least two species not found elsewhere, one of which, the *Chionis minor* of Hartlaub, or White Paddy, sheath-bill, and "sore-eyed pigeon" of sealers and whalers, I propose to give a short account of.

It was first seen by the transit-of-Venus parties and ship's company of the Swatara on the 11th of September, 1874, as that vessel was steaming up Royal Sound toward the spot selected as the observing station of the Kerguelen part of the expedition. It was a very pretty white bird, of about the size and much the appearance of a large pigeon, which came flying over from the shore, and alighted on the keel of a boat that had been secured bottom-up at the stern-davits. It walked up and down the keel of the boat, turning its head from side to side, and examining with great curiosity the crowd of interested spectators gathered on the poop, but showing not the slightest fear. After a few minutes it flew back again, with a note, while flying, not unlike the "chat-chat" of the common blackbird. That afternoon several were caught without difficulty; some were knocked down with stones, and some were actually taken, unhurt, by hand, being approached very gradually, and fed with crumbs until they came within reach.

The nearer examination thus afforded gave us a plump bird, much like a pigeon in size and shape, of pure white, very soft and downy plumage, and with bright black eyes, surrounded by a quite distinct, pale-pink eyelid (whence the name "sore-eyed pigeon"). The bill was black, conical, and very strong; the nostrils oval, placed at about the centre of the bill, and directed fore-and-aft. Covering just half of the nostril on each side was the curved anterior edge of a saddle-shaped horny sheath (Fig. 2), also black, and bestriding the posterior half of the bill. The pommel of the saddle was canted upward, so as to clear the bill by about three-tenths of an inch; its cantle was lost in the short feathers covering the forehead, and the flaps continued downward on each side, becoming soldered to the upper mandible near its base. On each side they sent up a black fleshy process (caruncle), deeply pitted with holes, which lay in contact with the upper eyelid. And, a fact not before observed, on clipping away the forehead-feathers, this black fleshy mass was found to extend entirely across the forehead, like the upper part of a black-silk domino, the little feathers which hide it during life passing through the holes with which it was everywhere pitted (Fig. 3). The legs were stout, pale flesh-colored, and scaly, with large, pavement-like knobs, but not what ornithologists call "scutellated," excepting over the upper surfaces of the toes. There were four toes, the first or hinder one being of good size for a hind-toe, and elevated above the rest, arising a little to the inner side of the leg. The claws were large, blunt, and black, and on the wrist-joint of each wing was a small black knob, like a spur (flesh-colored in females and young birds), which was afterward found to be supported by a distinct bony process, or exostosis, from the bone of the wing. The tail was very slightly rounded, and composed of twelve feathers—the wing-primaries were ten, and the first three of equal length.

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[1] *See* "Flora Antarctica," by Dr. J. D. Hooker (London, Reeve Brothers, 1847), vol ii., pp. 210–220, *inter alia*.

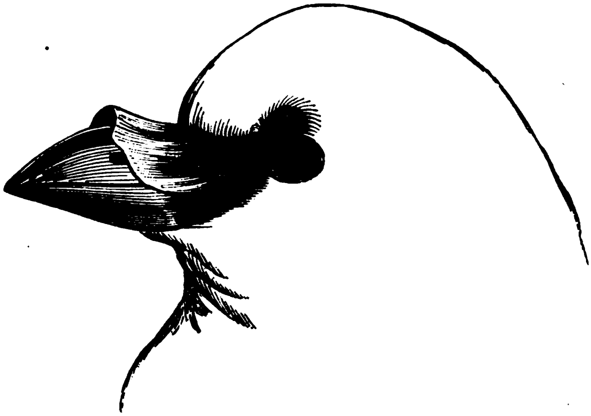

FIG. 2.—HEAD OF CHIONIS MINOR.

It may be as well to mention here that this species was erected by Dr. Hartlaub in 1841, when he wrote to the *Revue Zoölogique*[1] that he had found in the museum at Leyden a new species of chionis, "patrie inconnue." He called it *Chionis minor*, and distinguished it from Forster's *Chionis alba*, described in 1788, as being of smaller size, having a *black* bill and sheath, and a fleshy process of the same color over the eye. He also noted the color of the thickened eyelid and of the legs, and gave measurements of the principal dimensions. In 1842[1] appeared in the same journal a drawing of the head of the Leyden specimen, also from Dr. Hartlaub.

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[1] *Revue Zoölogique*, 1841, p. 5.

In 1849 it was figured by G. R. Gray,[2] being classed by him with the *Gallinæ* or fowl order, and associated with two other curious antarctic genera, called *Thinocorus* and *Attagis*. It would seem probable that Gray's drawing was made from the Leyden specimen also, since I have been able to find a record of only three other individuals (besides the eleven specimens brought to the National Museum by myself), all of which were sent to the Zoölogical Society. These were: a living specimen sent from Cape Town by Mr. Layard, of which the skin was exhibited to the society by Mr. Sclater, November 28, 1867;[3] and two skins received October 26, 1868,[4] also from Mr. Layard. All three of these specimens came originally from the Crozet Islands, which lie about six hundred miles to the west of Kerguelen, and present substantially the same natural history characteristics.

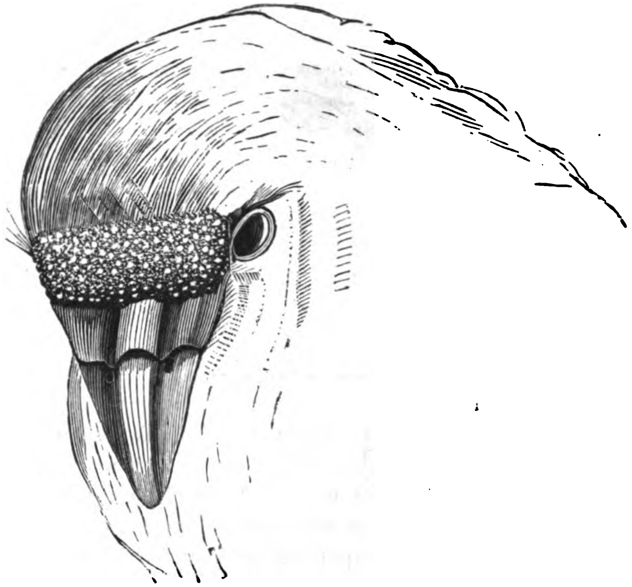

FIG. 3.—BILL OF CHIONIS, WITH FRONTAL FEATHERS CUT AWAY, TO SHOW THE CARUNCLE.

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[1] *Revue Zoölogique*, 1842, pl. 2, Fig. 2.

[2] "Genera of Birds," 1849, p. 522.

[3] "Proceedings of Zoölogical Society," 1867.

[4] Ibid., 1868.

An egg was received by the Zoölogical Society[1] in January, 1871, and described by Mr. Alfred Newton as the first of either species of the genus ever known, overlooking Mr. Layard's description of the egg of *C. minor* published in 1867.[2] Schlegel gives a figure and some description,[3] which I suppose, from the date, to refer also to the Leyden specimen, but have not yet been able to get access to the article.

If there ever were any other specimens, I have not been able to find the record of their receipt; and, whether there be or not, it is very evident that the birds are but little known to science, since the history of the species can be summed up in so few lines.

During a four months' residence on Kerguelen Island I had ample opportunity for observing the habits of the few living things which inhabited it, and none were more interesting in their ways than the chionis. Two or three lived near our huts, frequenting the rocks along the shore between tides. They were particularly plentiful upon a bold promontory called Malloy's Point, where many cormorants nested; and at another place, some two miles away, where the *débris* broken off from lofty, precipitous cliffs had made a sort of "lean-to" of irregular fragments of rocks. Here, likewise, was a nesting-place for cormorants, and also a great rookery of the curious "rock-hoppers," or crested penguins. These two birds were the chosen companions of the chionis, which lived with them on terms of perfect friendship and close association. One day (October 15th), seeing a large number of white specks on the farther side of Malloy's Point, I began to approach them very cautiously, so as to watch their movements at closer quarters. Caution proved, however, to be quite thrown away in that instance, since so great was the curiosity of the birds that they would scarcely get out of my way. When I finally sat down upon a rock and kept perfectly still for a few moments, they crowded around me like a mob of street-boys around an organ-grinder. Others flew up from more distant rocks, apparently called by the short, rattling croaks of those already near, and some came almost within reach of my arm. All seemed perfectly fearless and trustful, and very unlike in this respect to any other birds that I had ever seen. They ran with great swiftness over the rocks, stopping now and then to peck at a common green sea-weed (*ulva*), upon which they seemed to feed, shaking the water from it by a rapid, flirting motion of the bill. In running over the rocks they rather avoided the little pools of water left by the tide, seeming to dislike wetting their feet.

After sufficient time spent in observation, I changed the cartridges in my gun for others loaded with small shot, and moved off, so as to get far enough away to shoot two or three without tearing the skins; not without a good deal of compunction at destroying their friendly illusions. The interest of all was at once renewed; some started to follow me, making little swift runs and stopping short to look. Even after one had been shot they seemed rather startled than frightened by the noise of the gun. A few flew off for a short distance, but most remained, looking from me to the dead bird with great surprise, so that I was enabled to secure four specimens without moving from where I stood.

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[1] "Proceedings of Zoölogical Society," 1871, p. 57.

[2] Ibid., 1867, p. 458.

[3] Handl. Dierk., pl. 5—De Dierk., Fig., p. 232.

On subsequent occasions several specimens were captured alive, by hand, all that was necessary being to remain perfectly still, and feed them with bread-crumbs until they ventured within reach. When brought home, and let loose within-doors, they still showed no fear, running about the room actively, eating freely what was given them, and, oddly enough, fighting fiercely among themselves (a habit which I never observed an instance of when they were in the open air), but never using their wing-spurs as weapons. We put several of them into an extemporized coop, where they fought and pecked at the woodwork all night, chirping the while so like chickens that I once got up, thinking that some of our fowls had been fastened into the house. When shut up in this way they bore the confinement very illy, beating themselves constantly against the bars of the cage, and pecking fiercely at the woodwork. They would often stay around the house for several days, however, when let loose, running with our chickens and feeding with them like tame pigeons. One, whose wing had been clipped, remained for a week or more, but finally wandered off and was killed by the great southern skua which fills the place of a hawk in those regions.

Cuvier,[1] on the authority of Vieillot, attributes to the larger species a propensity for carrion, and a power of erecting the horny sheath, neither of which characters was to be found in those which we observed. The Australian species (identical with *Chionis alba* of Forster [2]) was named *C. necrophaga* by Vieillot on this account, but our chionis was one of the very few birds never found feeding on carrion. It was quite omnivorous in its diet, taking with equal readiness bread, vegetables, and fresh meat. The sheath was found to be firmly soldered to the base of the upper mandible, and therefore could not possibly be erectile.

About the middle of December (midsummer in the antarctic region) the sheath-bills began to break up into pairs, and to show signs of breeding. I never was so fortunate as to find a completed nest, although I often observed the pairs frequenting the crevices of fallen rocks, as if preparing to build. By the sealers, of whom several visited the island during our stay, I was informed that they build in the localities that I had attributed to them, constructing a nest of grass-stems, and laying three party-colored eggs; moreover, that they are exceedingly dexterous in misleading the egg-hunter as to the locality of their nests. The Rev. Mr. Eaton, naturalist to the English party, kindly gave me an egg which he had found on the day of our breaking up camp, January 10th, it being one of a nest of three, and evidently very fresh. It is a large egg, rather less than a hen's, pointed like a Guinea-fowl's, and marked by streaks and blotches of different shades of brown, which are said to vary much in hue in different specimens.

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[1] "Animal Kingdom," London, 1849, p. 250. [2] *Vide* "Genera of Birds," Gray, *loc. cit.*

The sheath-bill is not only "an interesting bird" to know, on account of its trustful and familiar habits, but has been something of a puzzle to ornithologists from the time of its first description, by Forster, in 1788.[1] Up to 1841 his species, *C. alba* (*necrophaga*, Vieillot) was the only one known, and has been quite variously classified. By G. R. Gray it was placed as a member of the fifth family (*Chionididæ*) of the order *Gallinæ*, a place retained for it in the British Museum Catalogue. Bonaparte associated it with gulls and petrels, as a member of his tribe *Longipennes*, order *Gaviæ*; and De Blainville,[2] after a careful anatomical examination, decided that its nearest affinities were with the *Oyster-catchers* (*Hæmatopus*). This last decision has been accepted as final by ornithologists in general. Mr. W. K. Parker[3] thus refers to another relationship: "There are certain curious, thoroughly *marine* plovers (chionis), in which the sheathing of the upper jaw is very perfect; they thus retain a struthious character, but have it in an exaggerated condition." Were this a proper place for the discussion of osteological details, it would be easy to point out other characteristics that might show a very plausible affinity of chionis to the *ostrich!*

Not to go deeply into the troubled and doubtful sea of the various grounds of classification of birds, it will perhaps not be out of place to mention some of the principal groups of characteristics upon which we rely to determine the place in Nature of any particular bird. First, there are the external parts: bill, eyes, plumage, feet, legs, etc., relied upon almost entirely by the older writers, and likely to hold their own, because of their convenience, for a long time yet. Then there is the digestive system, indicating also some of the affinities based upon *habit*. Third, and doubtless most to be relied upon, the structure of the skeleton, particularly of the skull (Huxley) and sternum, and the variations in muscular form and attachment. Last, but by no means, in my opinion, least, the habits and behavior of the bird during life.

Considered as to externals only, we find *Chionis minor* with the general form of a pigeon, the beak of a crow, surmounted by a sheath declared to be a characteristic of the ostrich family, with stout, knobby, short legs and feet, four-toed like a fowl's, but bare for a little way above the heel like a wading-bird. The "contour feathers" have a large downy "after-shaft," a characteristic of gallinaceous birds, and there is a thick, wattle-like caruncle on the forehead, a common feature of the swan family.

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[1] "Enchiridion Hist. Nat. Ins.," p. 37.

[2] "Sur la place que doit occuper dans le système ornithologique le genre *Chionis*, ou Bec-en-fourreau," De Blainville, Ann. Sc. Nat., 1836, vi., p. 93.

[3] "Osteology of Gallinaceous Birds," "Transactions of Zoölogical Society," p. 206.

The intestinal canal presents first a large *crop*, a rather long *proventriculus* or true stomach, well furnished with tubular follicles, a decidedly muscular gizzard or grinding-stomach, and two long appendages, the cæca, all features which are characteristic of gallinaceous birds. On the other hand we find the gastric follicles large and tubular, more like those of the swan than of any other that I know of, and quite unlike the lobulated follicles of the *Gallinæ*. The tendinous parts of the gizzard, moreover, are at the *sides*, instead of before and behind as is the (almost ?) universal rule.

It would probably be neither interesting nor profitable to recapitulate here the various resemblances to and differences from other families, presented by the bony framework of the chionis. The features of the skull are pretty evenly balanced between those characteristic of the plovers and of the gulls, with a slight sprinkling of the ostrich. The breastbone, a part to which great importance is attached by ornithologists in the determination of affinities, is decidedly like that of the gull family, between which and the plovers, considering only the skeleton, the genus must probably be placed, as De Blainville has already decided. That is to say, on summing up the various osteological peculiarities which mark the skeleton of this very composite bird, the greatest number is found to lie on the gull side.

Considered with regard to habits, however, the confusion grows worse again. It looks and flies like a pigeon, croaks like a crow, "chats" like a blackbird, or (in confinement) chirps like a fowl. It lives, to be sure, upon the seacoast, and feeds largely upon small marine animals and seaweed; but it dislikes wading, becomes perfectly helpless when accidentally in the water, and has no idea of swimming. Its diet is as various as that of fowls, and like them it swallows numbers of pebbles to aid digestion. Its natural tendencies seem to be toward domestication, or at least companionship with man. Like the plants of Kerguelen, it finds its nearest relatives in Patagonia, although Africa is so much less distant. How shall we explain all these incongruities? Perhaps it represents an older, more synthetic form, from which *Gallinæ*, *Waders*, and *Gulls*, are descended, preserving its own identity by its isolated habitat. Perhaps, as the ostrich represents an ancestral type, its apparent struthious characters may indicate real relationship after all, handed down from that distant time when all birds were more nearly allied than now. Since there certainly once was a time when Kerguelen Island, perhaps then part of a continent, was habitable, when the tree trunks that are now lying buried in its northern hills were upright and flourishing forests, perhaps the men of those days had also a bird tamed, like the domestic fowl; and perhaps the chionis is descended therefrom, and its liking for man is an inherited tendency.

Mr. Darwin exactly expressed the present attitude of this bird to science, as long ago as the voyage of the Beagle. He found a bird in Patagonia (*Thinochorus rumicivorus*) which "nearly equally partakes of the characters, different as they are, of the quail and snipe," and in this connection proceeds to remark: "A bird of another closely-allied genus, *Chionis alba*, is an inhabitant of the antarctic regions; it feeds on seaweed and shells on the tidal rocks. . . . This small family of birds is one of those which from its varied relations to other families, although at present offering only difficulties to the systematic naturalist, ultimately may assist in revealing the grand scheme, common to the present and past ages, on which organized beings have been created."

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THE PROPOSED INLAND SEA IN ALGERIA.

By JOHN D. CHAMPLIN, Jr.

AMONG the most revolutionary of the geographical schemes of the day are the projects of flooding portions of the African Sahara, and thus restoring to the sea what was once an integral part of it. In the Pliocene period, according to Sir Charles Lyell, the great desert was under water between latitudes 20° and 30° N., so that the southeastern part of the Mediterranean communicated with that portion of the Atlantic now bounded by the west coast of Africa. This is indicated not only by the presence of marine shells and other remains throughout the Sahara, but also by the radical difference between the fauna and flora north and south of it. What was formerly separated by a barrier of water is now separated by a barrier of sand.

There are two principal depressions in the Sahara, the basin called El-Juf, in the Sahel, north of the Middle Niger, which covers an area of about 126,000 square miles, and that of the *shotts* in the Algerian Sahara.

Mr. Donald Mackenzie, a British engineer, who has investigated the former depression, affirms that a long valley extends from its northwest corner to the Atlantic coast opposite the Canary Islands. It is only necessary, he argues, to cut through the accumulated sands at its mouth, which is laid down on the maps as the river Belta, to let in the waters and flood the entire basin. This scheme, advocated by Mr. J. A. Skertchly, General Sir Arthur Cotton, and others, will probably result in a thorough exploration of that part of the Sahara and its alleged outlet. The other project is in a more advanced state.

The depression of the *shotts* lies at the foot of the Aures Mountains, spurs of the main chain of the Atlas, partly in the province of Constantine in Algeria, and partly in Tunis. Its western extremity is in latitude 34° 30′ N., longitude 5° 65′ E., and it extends thence eastward two hundred and thirty-five miles to within about thirteen miles of the foot of the Gulf of Cabes, or Gabes, in the Mediterranean, anciently the Lesser Syrtis, from which it is now separated by an isthmus of sand. The breadth of the depression is about thirty-seven miles. Within these limits lie several connected lake-beds, called by the Arabs *shotts* or *sebkas*, *shott* signifying properly the bottom of a lake left dry by evaporation, and *sebka* a saline marsh. The largest of these are Shotts Melrir, or Melgig, whose eastern extremity is called Es-Selam, El-Rharsa, or Gharsa, and El-Jerid, or Fejej. About one-half is in French territory, the Tunisian boundary line cutting the western bank of Shott El-Rharsa.

This great depression is supposed to mark the site of the lake of Triton, or Tritonis, mentioned by Herodotus, Scylax, Pomponius Mela, Ptolemy, and other ancient writers, and around which were localized the Greek divinities Poseidon and Athena, and the Argonautic myth. Into it was driven the good ship Argo, when blown from her course around the Malean promontory by an adverse wind. Jason, lost among the shallows, propitiated the local divinity, Triton, son of Poseidon, by presenting him with the brazen tripod, whereupon the god, filled with prophetic heat, foretold that a hundred Grecian cities would spring up around Tritonis whenever a descendant of the Argo's crew should seize and bear away the precious gift. Through the foresight of the subtle Libyans, who hid the tripod, the prophesy was unfulfilled, but many noble cities were afterward built north and east of Tritonis, and along the coast of Syrtis Minor. Indeed, so numerous were they, and so flourishing as trade-centres, that the country was named Emporia. All the ancient writers agree in praising it for its wonderful riches and fertility. Says Scylax: "This region, which is occupied by Libyans, is most magnificent and fertile; it abounds in fine cattle, and its inhabitants are most beautiful and wealthy." It was within the dominion of Carthage, and here were the storehouses and granaries from which Rome's great rival supplied her troops.

But now all is changed. The drying up of the ancient sea has deprived the land of its moisture, and the once fertile plain between the mountains and the north bank of the *shotts* is, with the exception of a few oases, a sterile waste. Nothing remains to tell of former greatness but ruins, which are said to be scattered over the country far up into the mountains.

Herodotus, the most ancient writer by whom Tritonis is mentioned, says that it was fed by the great river Triton; but modern research has failed to identify it, there being now but a few rivulets which enter it from the mountains on the north, or lose themselves in the desert. If there ever was a great river flowing into it, its bed has been obliterated by the shifting sands.

At a later date Tritonis appears as three connected lakes, called, respectively, Libyca, Pallas, and Tritonis, which some recognize in the Shotts Melrir, El-Rharsa, and El-Jerid. It is probable that the mouth became gradually blocked up with sand, and the lake, no longer receiving sufficient water from the Mediterranean to supply the waste from evaporation, separated into several smaller seas, which, by continued desiccation, became transformed at last into their present condition. When this took place can only be conjectured, but it was probably in the early centuries of the Christian era. The Arabs preserve the tradition that Shott Es-Selam was a lake at the time of the Mussulman conquest. They also aver that the lake bed has not been covered with water during the past hundred years.

Although it has long been known that this desert basin was lower than the Mediterranean, nothing was positively settled in regard to it until 1873, when Captain Roudaire, a staff officer of the French army in Algeria, ascertained the altitude of Biskra, and by a series of levelings from that point proved that the western extremity of Shott Melrir was twenty-seven metres, or nearly eighty-nine feet, below the level of the sea. The publication of his investigations and an exhaustive discussion of the probabilities of success in reopening the ancient lake, in the *Revue des Deux Mondes* (May, 1874), aroused interest in the project in hope not only of reclaiming the country, but also of opening a commercial avenue to Southern Algeria. The French have long sought to deflect the caravan trade of Middle Africa, which is now mostly monopolized by Morocco and Tripoli, to Algiers, but in vain, the increase in prices to be obtained in Algiers not being sufficient to compensate for the increase in distance. But with an inland sea the circumstances would be changed. The country around it would resume its ancient character of a littoral province, and the caravan routes of the Sahara would converge toward a port established on its southern border, whence the gold dust, ivory, gums, and ostrich feathers of Soodan would be shipped directly to Europe to the detriment of the Mohammedan markets. Tougourt, too, the French military post in southern Algeria, now distant nearly two hundred and fifty miles from the port where its provisions are landed, would then be only about forty miles from the sea.

Captain Roudaire discusses also the probable climatic changes which would ensue from reopening the Bay of Triton. He argues that the northwest winds, which prevail in summer, would be less violent than now, and the southwest winds, which blow during the remainder of the season, would be charged with vapor and cause a greater fall of rain in Algeria, Sicily, and South Italy, without materially modifying the climate. This increased rainfall would restore the land to its ancient fertility, and the region of the *shotts* would again become the home of a thriving population and the granary of North Africa.

To flood the *shotts* would require only the piercing of the isthmus between El-Jerid and the Gulf of Cabes. This is about thirteen miles wide; but Captain Roudaire thinks that the curve of altitude would reach zero at about eleven miles from the Mediterranean, which would materially reduce the amount of excavation. As the evaporation would be much greater than in the Mediterranean, a large and constant flow of water from the latter would be necessary to keep it at its proper level. This would require a canal at least one hundred yards wide, which could be constructed, it is calculated, at a cost of twenty million francs. To this amount would have to be added a sufficient sum to compensate for the destruction of property in the Tunisian part of the depression, which would ensue from its submersion. Besides the towns of Nefta and Tozer, there are many douars, or villages, in the oases, surrounded by cultivated lands and date plantations. These are generally in the lowest part of the depression, for there only can potable water be found, the higher land being without springs.

The superior council of Algeria, comprehending the immense advantages which would accrue to the colony from the consummation of this scheme, voted in 1873 a sum sufficient to continue the survey, and a well-appointed expedition, under command of Captain Roudaire, made a thorough examination of the bed of the Algerian portion of the *shotts* in the following year. The French Geographical Society, taking a national as well as a scientific interest in the question, also contributed money in furtherance of the object, and deputed M. Duverrier, one of its members, to accompany the party. The expedition entered the depression on the northwest side of Shott Melrir. The soil there is sand and marl, charged with salt. The many streams which traverse the country have, with a few exceptions, no running water, excepting in winter and spring, the season of rains and of the melting of snow in the mountains. These rivers usually divide, before reaching the *shotts*, into several branches, which again subdivide and form innumerable ramifications. Where these begin to disappear, the soil, which is charged with salt and almost bare, swells and cracks, and the water sinks, when the crust reforms. Farther east are naked plains of marl, level and smooth, and covered with a white incrustation which produces frequent mirages. On the extreme west the river beds enter Shott Melrir with separating. On the south side are sand hills and moving sands.

All the *shotts* are alike in general features. All have flat bottoms with an inclination too slight to be perceptible to the eye, and all form basins which receive water-courses. The soil of all contains a great quantity of salt, which whitens their bed in dry places. But each has its peculiarities. The west end of Melrir has a bottom of sandy earth, strewed along the borders with small round and polished quartz pebbles. Near the banks is a meagre salsuginous vegetation. In the interior its bed is clay, filled with crevices, but moist; farther on the crevices close and the saturated marl and clay form quagmires in which horse and rider might be swallowed up.

The eastern end of Shott Melrir, which is called Shott Es-Selam, presents other general characteristics. Near the banks the bed is sandy, but toward the middle it forms a hard crust of salt and sand. Elsewhere the soil is a hard surface of clay, which shines in the sun. Mirage is very frequent in this *shott*.

Between the Shotts Es-Selam and El-Rharsa the expedition first began to encounter obstacles which may seriously interfere with the projected inland sea. In the intervening country are numerous smaller *shotts*, of which that called Mouia-el-Tadjer is the largest. This shott has a long extension stretching southward, called El-Hadjila, connected with which on the east is Shott Mouia-el-Tofla. Measurements in the highest part of the bed of the latter showed it to be more than eleven feet above the level of the sea. A low ridge separates it from Shott El-Asloudg, the western border of which is only between six and seven feet below the sea, and the eastern about twelve feet. Between this and Shott Bou Dhouil, which is little more than eight feet above the sea, is an extended ridge of sand. Bou Dhouil is but a short distance from the Tunisian frontier and the great Shott El-Rharsa. At this point the expedition ceased its labors and returned to Biskra, convinced that a secondary canal connecting El-Rharsa and Melrir, or some of the *shotts* belonging to its system, would be necessary before the proposed inland sea could be extended far enough west to benefit Algeria. This would entail a considerable additional expense, but whether large enough to seriously affect the realization of the scheme cannot be known until the publication of the official reports.

This expedition made no investigation of the Tunisian portion of the depression, being evidently under the impression that no insurmountable obstacle existed in that part. Whether this belief was founded on the accounts of the ancient geographers or on an actual knowledge of the country is not apparent, but it is said that levels were taken from Shott El-Jerid to the Mediterranean several years ago by Captain Pricot de Sainte Marie, of the staff of the French army in Algeria. His report, which is deposited in the archives of the Ministry of War in Paris, must have been favorable, else the survey of the Algerian *shotts* would scarcely have been undertaken.

It is reported, however, on the contrary, that a survey was made of the same isthmus in 1874 by M. Fuchs, a French geologist employed by the government of Tunis to investigate the mineral resources of the country, who discovered that physical obstacles exist of a nature to render a canal impossible; that a range of sandstone hills lies between El-Jerid and the sea, and that the bed of El-Jerid itself is considerably above the sea. If this be true, not only is the proposed inland sea an impossibility, but we must also relegate to the domain of fable the accounts of the great lake of Tritonis, or assign it to another locality.

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ANIMAL PARASITES AND MESSMATES.

THE fight for a foothold in the animal world brings the combatants into many strange relations, few of which are more curious and interesting than those existing between the creatures popularly known as parasites and the animals which furnish them support. In these relations all grades of pauperism and criminality are represented. There is the miserable wretch that lives entirely at the expense of others, finding it easier to die than to help himself; the poor weakling, willing enough to do what he can, but sure to starve to death if left wholly unassisted; the petty thief that sneaks into his neighbor's premises and steals a portion of his store; and the audacious robber that boldly appropriates another's substance, and not unfrequently adds murder to his list of crimes. In his entertaining and instructive work on "Animal Parasites and Messmates,"[1] from which this article and its illustrations are mainly taken, Van Beneden makes these different degrees of dependence the basis of a rough but convenient classification, by which he separates, what have hitherto been known as parasites, into three groups, named respectively *messmates*, *mutualists*, and *parasites*.

The messmate is one that takes his place at his neighbor's table to partake with him of the product of the day's toil. He does not live directly at the expense of his host, but, abiding with him, obtains thereby better opportunities for securing a supply of food. This mode of getting a living is very common, and a curious thing about it is that animals comparatively high in the scale of organization do not scruple to quarter themselves upon others of much inferior grade. The fish known to naturalists as fireasfer lives in this relation. He takes up his lodgings in the digestive tube of a holothurian, and, regardless of the rules of hospitality, appropriates a portion of all the food that enters. He thus manages to get himself served by another better provided than he is with the means of fishing. Dr. Greef found at Madeira a holothurian over a foot long, in which one of these fishes was enjoying a peaceful and vigorous existence. Other fishes besides the fireasfer have been found in similar quarters; indeed, the situation appears a very favorable one for this mode of life, since not only fishes but crustaceans here take up their abode, sometimes in considerable numbers. Prof. Semper has seen holothuriæ in the Philippine Islands which bore considerable resemblance in this respect to a hotel with its *table-d'hôte.*

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[1] No. XIX. "International Scientific Series," New York, D. Appleton & Co., 1876.

A somewhat more excusable piece of pauperism is found in the case of an eel, which ensconces itself in the branchial sac of that curious fish known as the angler, or fishing-frog (Fig. 1), where he afterward plays the part of a messmate. Although the eels generally get their living easily, the angler possesses fishing-implements which are wanting in them, and, when immersed in the ooze, it carries on a fishery sufficiently abundant for both. This relationship was first observed by Risso in the Mediterranean; the same fish in more northern seas has since been found to harbor, in like manner, an amphipod crustacean.

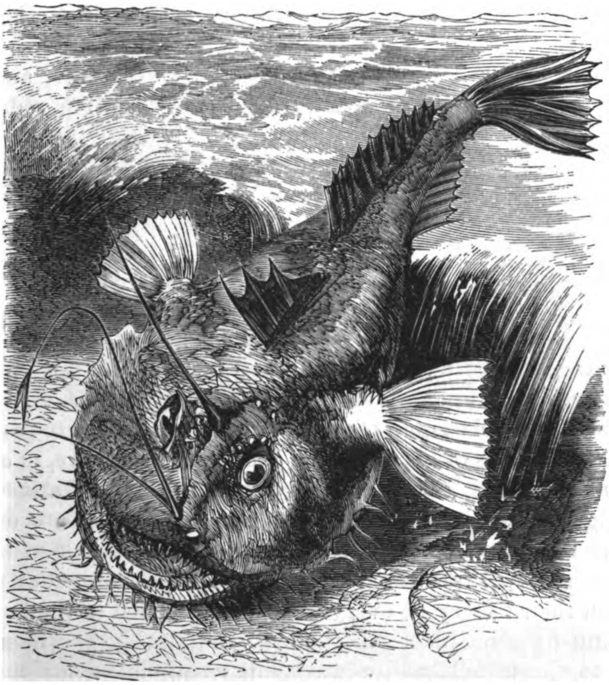

FIG. 1.—THE ANGLER-FISH.

Another remarkable example of this kind of association among fish was made known by Reinhardt, of Copenhagen. A siluroid fish occurring in Brazil, and possessed of numerous barbules that make it successful as a fisherman, lodges in the cavity of its mouth some very small fishes, that for a long time were supposed to be young siluroids; it was believed that the mother brought her progeny to maturity in the mouth, as marsupials do in the abdominal pouch, or as some other fishes do. But this is a mistake. The supposed young are perfectly developed adult fish, that, instead of living by their own labor, prefer to install themselves in the mouth of a neighbor, and take tithes of the morsels which he swallows.

The little crab that makes its abode within the shell of the edible oyster (Fig. 2) is a true messmate, and the oyster is but one of many bivalve mollusks that give shelter and partial support to these diminutive crustaceans. These crabs, called by naturalists *Pinnotheres*, though in one sense dependents, are at the same time of great service to the animals within whose shells they receive protection. Van Beneden says of them: "The pinnothere is a brigand who causes himself to be followed by the cavern which he inhabits, and which opens only at a well-known watchword. The association redounds to the advantage of both; the remains of food which the pinnothere abandons are seized upon by the mollusk. It is the rich man who installs himself in the dwelling of the poor, and enables him to participate in all the advantages of his position. The pinnotheres are, in our opinion, true messmates. They take their food in the same waters as their fellow-lodgers, and the crumbs of the rapacious crabs are doubtless not lost in the mouth of the peaceful mussel. . . . Little as they are, these crabs are well furnished with tackle and advantageously placed to carry on their fishery in every season; concealed in the bottom of their living dwelling-place, they choose admirably the moment to rush out to the attack, and always fall on their enemy unawares. Some pinnotheres live in all seas, and inhabit a great number of bivalve mollusks."

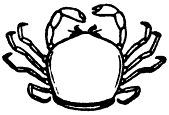

FIG. 2.—OYSTER CRAB.[1]

In the examples thus far cited, and in many more that have been observed, the dependent forms are free to depart whenever they choose, and are therefore called *free messmates*. Though for a time giving up their liberty, they sooner or later resume it, in possession of all their organs for fishing and locomotion, and in all respects fitted to live an independent life. There are others, however, that enter into the same sort of association, and make the relation a permanent one: these are known as *fixed messmates*. They are free in their youth, but, as maturity approaches, and the cares of a family are thought of, a host is selected in which they establish themselves, and, throwing aside their fishing and locomotive apparatus, they renounce the world, and even part with the most precious organs of animal life, not excepting those of the senses.

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[1] From Morse's "First Book of Zoölogy."

The most interesting fixed messmates are those cirripeds or barnacles which, under the names of *Coronula* and *Tubicinella* (Figs. 3 and 4), cover the skins of whales. They are, like all the rest, free while young, but later they take shelter on the back or on the head of one of these huge cetaceans, and, having once chosen their abode, are afterward permanent tenants. Each whale lodges a particular species, and

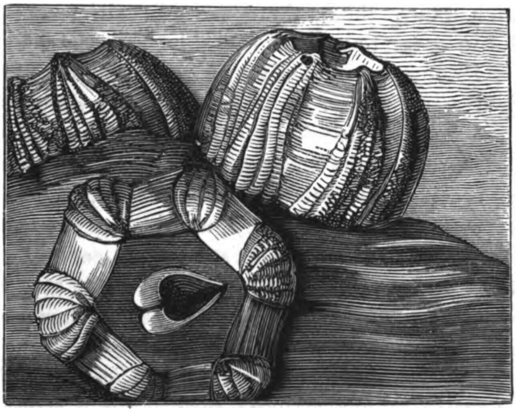


Fig. 3.—Coronet Barnacle (*Coronula diadema*).

the manatee, marine turtles, and various sea-snakes, have also their different sorts. Others establish themselves on their own immediate relations and on other crustaceans. A pretty genus found near Cape Verd, living on the carapace of a large lobster, spreads itself over the

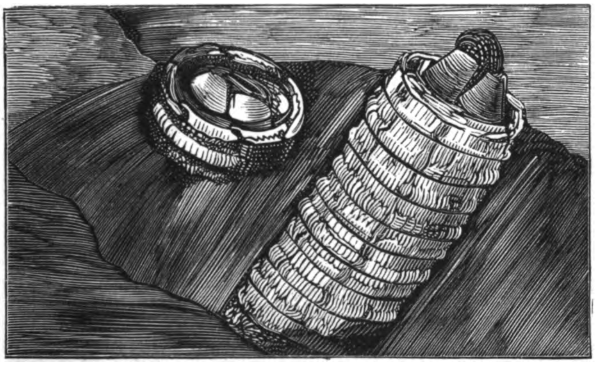


Fig. 4.—Burrowing Barnacle (*Tubicinella trachealis*).

centre of the lobster's back, and looks not unlike a bouquet of flowers. Fig. 5 shows a fixed messmate attached to a sertularian.

Mutualists, as the name suggests, are animals which live on each other; and, though usually confounded with messmates and parasites, they differ from both in making some sort of return for benefits obtained. Many insects shelter themselves in the fur of the mammalia or in the down of birds, and remove from the hair or the feathers the pellicle and epidermal *débris* which encumber them. At the same time they minister to the outward appearance of their host, and are of great use to him in a hygienic point of view. Animals living in the water are similarly served by minute crustaceans. These sometimes establish themselves on fishes, and, if there are no scales of the epidermis which annoy them, there are mucosities which are incessantly renewed in order to protect the skin from the continual action of the water. Among the insects found on the skins of mammals and birds that yield some return for the hospitality they receive, those belonging to the family *Riciniæ*, and commonly known as ticks, are very numerous. Among the many generic divisions, one of the most interesting has received the name of *Trichodectes;* it contains twenty species, one of which lives on the dog, another on the cat, another on the ox; in a word, there is a distinct species on each of the domestic mammals. The species infesting the dog has lately attracted especial attention, from the circumstance that it lodges the larva of the *Tænia cucumerina*, a tapeworm common to dogs. The cock, the turkey, and the peacock, carry each a distinct species of *Riciniæ*, and oftentimes several species are found on a single bird. Fig. 6 represents a form which infests the pygarg or sea-eagle.

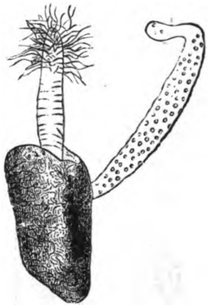


FIG. 5.—OPHIODENDRUM ABIETINUM ON *Sertularia abietina.*

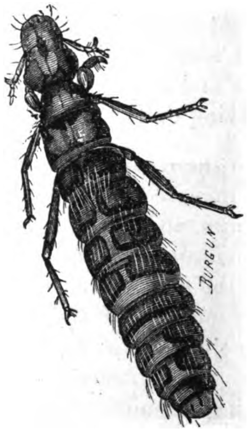
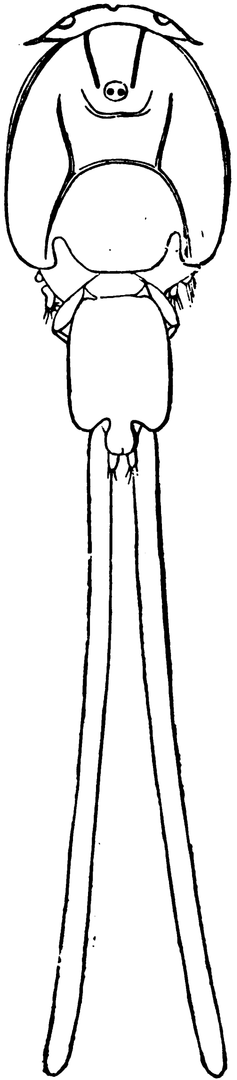


FIG. 6.—RICINUS OF THE PYGARG.

Fishes harbor crustaceans instead of insects, frequently in enormous numbers. They live on the produce of cutaneous secretions, and thus, like the ticks, are of service to their hosts. The *Caligi* and *Arguli*, known usually as fish-lice, are among the most common of these, and both are elegant forms, that change but little in appearance in the course of their lives, and, although permanent tenants when once established, they retain their fishing-tackle and locomotive apparatus. The greater number of osseous fishes lodge *Caligi* on the surface of their skin, where the tiny creatures fix themselves by means of strong cables. Fig. 7 represents a species that lodges on the cod, and it in its turn affords a resting-place for another form—the *Udonellæ.*

A curious creature, with an equally curious function, that entitles it to a place among mutualists, was discovered some years ago among the eggs of the lobster, by Van Beneden, who thus describes it: "It is known that lobsters, as well as crabs, and the greater part of the crustacea, carry their eggs under the abdomen, and that these eggs remain suspended there until the embryos are hatched. In the midst of them lives an animal of extreme agility, which is, perhaps, the most extraordinary being that has been subjected to the eyes of the zoölogist. It may be said, without exaggeration, that it is a biped, or even quadruped, worm. Let us imagine a clown from the circus, with his limbs as far dislocated as possible, we might even say entirely deprived of bones, displaying tricks of strength and activity, on a heap of monster cannon-balls which he struggles to surmount; placing one foot, formed like an air-bladder, on one ball, the other foot on another, alternately balancing and extending his body, folding his limbs on each other, or bending his body upward like a caterpillar of the *Geometridæ,* and we shall then have but an imperfect idea of all the attitudes which it assumes, and which it varies incessantly. It is neither a parasite nor a messmate; it does not live at the expense of the lobster, but on one of the productions of these crustaceans, much in the same manner as do the *Caligi* and the *Arguli.* The lobster gives him a berth, and the passenger feeds himself at the expense of the cargo; that is to say, he eats the eggs and the embryos which die, and the decomposition of which might be fatal to his host and his progeny. These *Histriobdellæ* have the same duty to perform as vultures and jackals, which clear the plains of carcasses. That which causes us to suppose that such is their appropriate office is, that they have an apparatus for the purpose of sucking eggs, and that we have not found in their digestive canal any remains which resemble any true organism."

OF THE NATURAL SIZE.



CALIGULUS ELEGANS. FEMALE.

FIG. 7.

True parasites are beings entirely dependent on their neighbors for support; unable to provide for themselves, they are fed wholly at the expense of others. It is generally believed that they are an exceptional class of organisms, constituting a group by themselves, and knowing nothing of the world outside the organ which shelters them. This is an error. Representatives of all the principal divisions of the animal kingdom below the vertebrate are found pursuing this mode of life. There are few parasites that are not wanderers at some period of their lives; and it is not uncommon to find some which live alternately as noblemen and as beggars. Many are paupers only during infancy, or at the approach of adult age, living at other times a comparatively free and independent life. Nor are all the members of a species necessarily parasitic; sometimes it is only the female that takes the relation of a dependent, the male continuing his nomad life. Again, there are cases where, the female being provided for, the male relies on her for support, and thus the charitable animal which comes to her help is laid under contribution by the whole family.

Parasites present an extraordinary variety of forms, and differ very widely in size and appearance, these differences being often remarkable between the sexes of the same species. The male of the urubu of Brazil has the usual form of a round long worm, while the female resembles more than any thing else a ball of cotton, not having the slightest analogy with the other worms of the order. As to the enormous proportions parasites may attain, Boerhaave mentions a bothriocephalus 300 ells[1] in length; and, at the Academy of Copenhagen, it was reported that a solitary tapeworm (*Tænia solium*) had been found 800 ells long. Parasites are found in every region of the globe, but, like other animals, they observe the laws of geographical distribution. Some, like the leeches, take their food, and then detach themselves until the demand for food returns, never becoming identified for any length of time with their host. Others, like the lernæans, commence their parasitic existence when approaching maturity, and thereafter are permanent dependents; others, again, like the ichneumons, begin life as parasites, and on reaching maturity assume and maintain an independent existence; while still others, like the tænia, are parasitic from first to last, although changing their abode at a certain stage of development.

All animals, man included, have their parasites, which usually come from without, those entering the body being generally introduced with the food or drink. No organ is exempt from their incursions, as they have been found in the brain, the ear, the eye, the heart, the blood, the lungs, the spinal cord, the nerves, the muscles, and even the bones. Cysticerci have been seen in nearly all these situations, and worms of various kinds are common in the cavities of the body, as well as in many of the solid organs, such as the muscles, liver, and kidneys. As a rule, those which inhabit a temporary host install themselves in a closed organ; in the muscles, the heart, or the lobes of the brain; those, on the contrary, which have arrived at their destination, and which, unlike the preceding, have a family, occupy the stomach, with its dependencies the digestive passages, the lungs, the nasal fossæ, the kidneys, in a word, all the organs which are in direct communication with the exterior, in order to leave a place of issue for their progeny.

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[1] The Flemish ell is probably meant: this is 27 inches long.

A single animal may carry, not only a great number of individuals of the same species, but many different species of parasites, and this, too, without any apparent impairment of health. Indeed, in some countries their presence is considered indispensable to the highest health, the Abyssinians, for example, deeming themselves below par unless they nourish one or many tapeworms. Nathusius speaks of a black stork which lodged 24 *Filariæ* in its lungs, 16 *Syngami tracheales* in its tracheal artery, more than 100 *Spiropteræ* within the membranes of the stomach, several hundred of the *Holostomum excavatum* in the smaller intestines, 100 of the *Distoma ferox* in the large intestines, 22 of the *Distoma hians* in the œsophagus, and a *Distoma echinatum* in the small intestine. In spite of this affluence of lodgers, the bird did not appear to be the least inconvenienced. Krause, of Belgrade, mentions a colt, two years old, which contained more than 500 *Ascarides*, 190 *Oxyures*, 214 *Strongyli armati*, several million *Strongyli tetracanthi*, 69 *Tænia*, 287 *Filariæ*, and 6 *Cysticerci*. Well supplied as these animals appear to have been, when we consider the number of eggs a single worm may produce, the wonder is that parasites are not more numerous than they are: 60,000,000 eggs have been counted in a single *nematode*, and in a single tapeworm more than 1,000,000,000 eggs have been found!

While nearly all animals, including parasites themselves, are made to contribute to the support of others, those to which man gives food and lodging are of greatest interest, and he is by no means scantily provided with this class of dependents. Four different *cestodes*, or tapeworms, live in his intestines; three or four *Distoma* lodge in his liver, intestines, or blood; nine or ten *hematodes*, or round worms, inhabit his digestive passages or flesh; and *cysticerci*, *echinococci*, and *hydatids*, are also among his guests. He provides a living for three or four kinds of lice, for a bug, for a flea, and two ascarides, without mentioning certain inferior organisms which lurk in the tartar of the teeth, or in the secretions of the mucous membrane of the mouth. Some of these are confined to him exclusively, others may also find a home on the lower mammalia; some make his body their home while passing through a single stage of development, beginning or finishing the process, as the case may be, in the body of another animal; and others, again, are but day-boarders, taking their meals at his expense, and finding lodgings elsewhere.

Leeches are true parasites, although asking only food and taking care of themselves in the intervals of their meals. They suck the blood of their victim, and, when gorged to the very lips, fall off and perhaps for many weeks have no further need of assistance. The vampires of South America obtain support in a similar way, and are just as truly parasitic, although otherwise leading an independent life. The best-known leeches are those which prey on man and other mammals; but some are found which attack animals of still lower grade, especially the fishes. The organization of the leech appears always to be proportioned to that of the host which it frequents, the lower the grade of the latter the simpler the structure of the former. Those living on the mollusks are inferior to those found on fishes, and these again rank below the sorts that attack the mammalia. Fig. 8 (1, 2, 3, 4) shows the different appearances assumed by the skin after a leech-bite; Fig. 9 represents the structure of the jaws; and Fig. 10 is a longitudinal section of the body of the leech. The letters

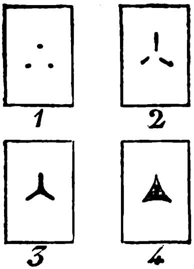


Fig. 8.

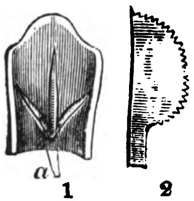


Fig. 9.

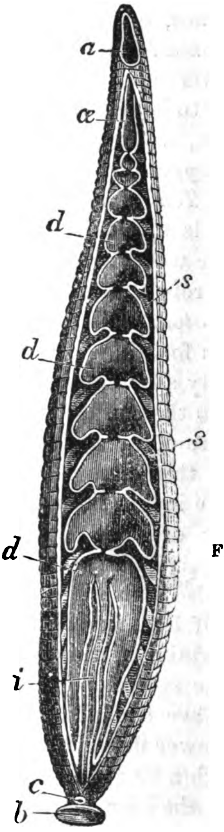


Fig. 10.

Fig. 8.—Different Forms of the Bite of a Leech.
Fig. 9.—1. Sucker, open; *a*. Jaws. 2. One of the Jaws magnified.
Fig. 10.—Section of a Leech: *a*, Anterior Sucker; *b*, Posterior Sucker; *c*, Anus; *d*, Stomach; *œ*, Œsophagus; *i*, Intestine; *s s*, Glands of the Skin.

d d d indicate the different cavities of the stomach that are successively filled when the creature feeds. These animals vary greatly in size, appearance, and mode of life. Some are exceedingly minute, and of delicate structure, while others have been seen that were a foot and a half long. Most of them are highly voracious, taking sometimes the weight of their bodies in blood at a single meal. Generally they are aquatic, but a few species are met with in the brushwood and low forest growth of the tropics, where they attack both man and beast when opportunity offers.

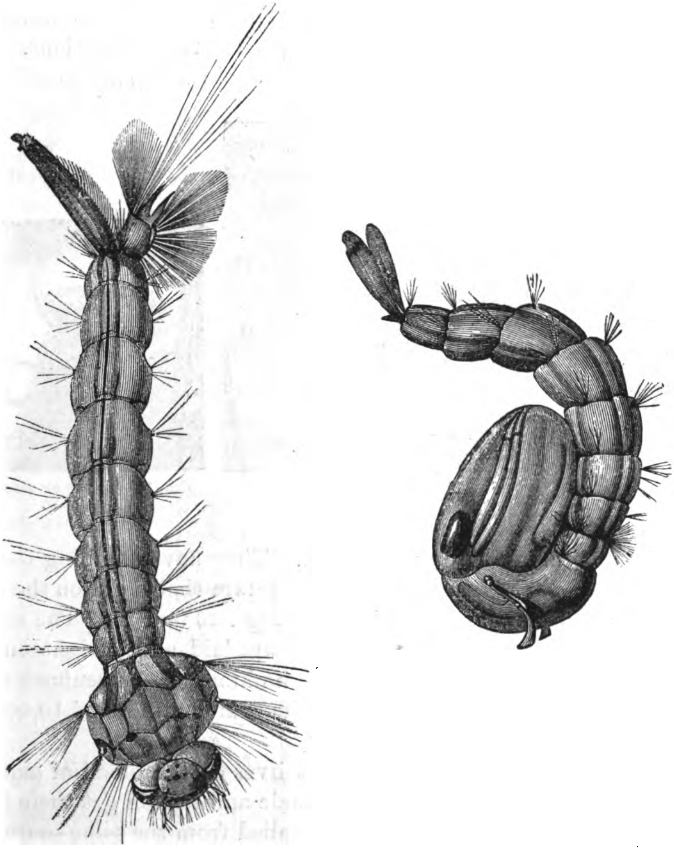


FIG. 11.—GNAT (*Culex pipiens*), LARVA AND NYMPH.

Gnats or mosquitoes are parasites that get their living in much the same way as the leeches, that is, they suck the blood of other animals, man being their most common victim. They differ from the leeches, however, in the fact that only the females are greedy of blood, the males living on the juices of plants. The females pierce the skin by means of an auger with teeth at the end, and after sucking their fill distill into the wound a liquid venom which occasions the irritation that follows the bite. Fig. 11 shows the form of the larva and nymph of this insect. The former will be recognized as the little "wriggler" that may be seen in such numbers in stagnant water in summer. Fortunately, these insects are harmless until they acquire wings, and after that their life is a short one; but, unfortunately, they breed at an enormous rate, and thus maintain the supply, to the infinite annoyance of man and other tender-skinned animals.

Another blood-sucking parasite of both man and beast, whose staying tendencies are proverbial, is the louse. Fig. 12 represents the species that inhabits the head of man. The mouth of this insect consists of a sucker contained in a sheath, without articulations. It is armed at the point with retractile hooks, within which are four bristles that aid in breaking through the skin. They have climbing feet terminated by pincers, with which they maintain their hold on the hairs. The sucker and claw are illustrated in Figs. 13 and 14. The *nits*, or eggs, hatch in five or six days after they are laid, and in eighteen days more the creature is able to reproduce its kind. Leeuwenhoek calculated that two females might become the grandmothers of 10,000 lice in eight weeks.

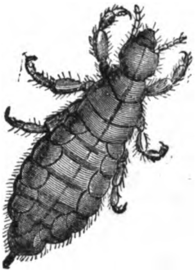


FIG. 12.—LOUSE OF THE HEAD.

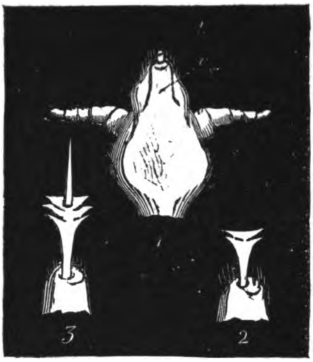


FIG. 13.—LOUSE OF THE HEAD. 2, 3, Sucker.

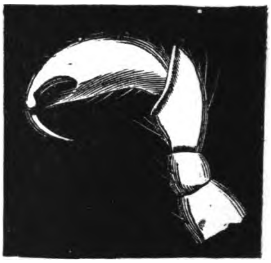


FIG. 14.—LOUSE OF THE HEAD, CLAW.

A not less annoying parasite that lives on the blood of man and the higher animals is the flea. Both male and female get their living in this way, and even the larvæ are supplied from the same sources by the mother, who sucks for herself first, and then divides with her young ones. The ordinary flea (*Pulex irritans*, Fig. 15) is common in both Europe and North America. It may be called a fly without wings, and, together with others of its kind, forms a distinct family under the name *Pulicidæ*. The four principal species are *Pulex irritans* of man, *Pulex canis* of the dog, *Pulex musculus* of the mouse, and *Pulex vespertilionis* of the bat. Great numbers of human fleas, half as large as the common fly, are found in summer on the sandy shores of the Mediterranean, in the neighborhood of Cette and Montpellier. Their presence in this locality is due solely to the circumstance that large numbers of persons of both sexes and all classes come to these places to bathe, and, laying their clothes upon the sand, leave there a part of their vermin. Van Beneden suggests the surgical employment of the flea as an homœopathic phlebotomist, and recommends this region as an excellent source of supply in case his suggestion is adopted. The largest fleas are found upon the bat; they sometimes annoy the horse, and there is a species peculiar to monkeys.

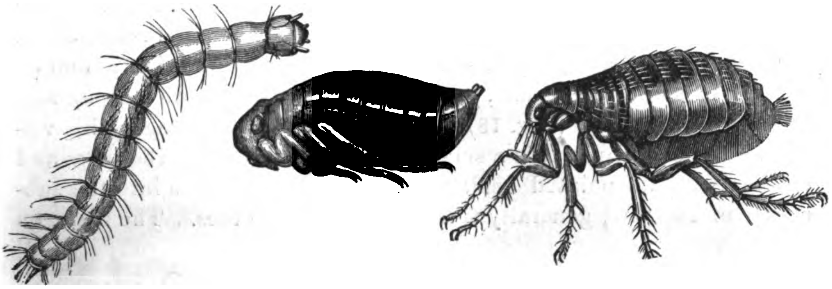


FIG. 15.—HUMAN FLEA (*Pulex irritans*).

The minute creatures known as *Acari*, or mites, are most of them parasitic, and they are very widely distributed. They are not true insects, but belong to the *Arachnida*, having four pairs of legs like the spiders, with head and thorax closely united. The group includes those disgusting creatures the itch-mites, magnified representations of which are shown in Figs. 16 and 17. The mammalia have each

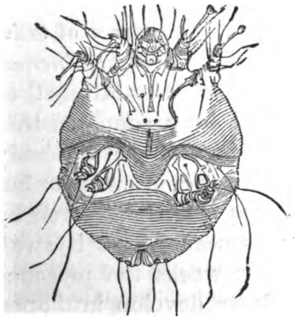


FIG. 16.—SARCOPTES SCABIEI, OR MALE ACARIUS OF THE ITCH. THE LOWER SURFACE.

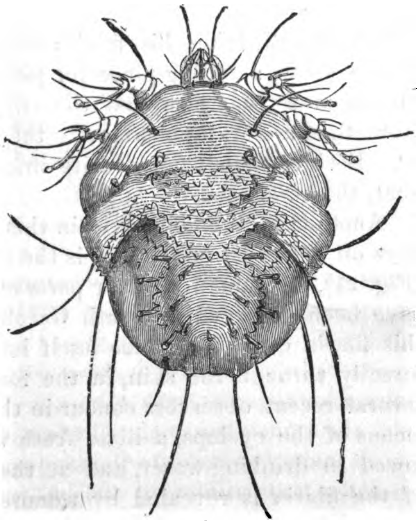


FIG. 17.—SARCOPTES SCABIEI, FEMALE. THE UPPER SURFACE.

their particular species, which in many cases are the cause of peculiar skin-affections. Since the presence of these animals constitutes the disorder, it may be easily caught; man may communicate it to the domestic animals, and they may also give it to him; it is only the genus *Sarcoptes*, however, that may be thus transferred from animals to man.

The true parasites just described, and many others like them, are nourished by the blood of their neighbors, but they never establish themselves in the organs of their host, being free throughout their lives. There is another class that live in freedom while young, but when arrived at mature age, and the cares of a family are soon to be assumed, they change in appearance, choose a host, and settle down for life. The chigoe, a parasite of man in South America, is one of these. It is only the female, however, that demands both lodging and provisions, the male (Fig. 18) being contented with pillaging his victim as he passes by. It is a small species, which pierces the shoes and clothes with its pointed beak (Fig. 19), and penetrates into the substance of the skin, generally selecting that of the toes. The male, as just remarked, takes his food and resumes his wanderings, but the female seeks a hiding-place for permanent abode, and then grows to such a monstrous size that the entire insect appears to be nothing more than a mere appendage to the abdomen, as may be seen in Fig. 20. Besides man, this parasite infests the dog, the cat, the pig, the goat, the horse, and the mule.

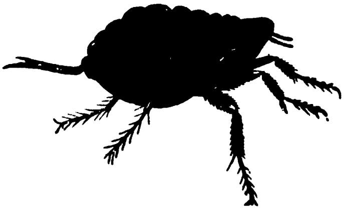


FIG. 18.—MALE CHIGOE.

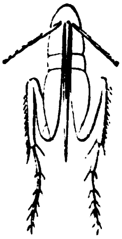


FIG. 19.—HEAD OF CHIGOE.

Another form coming within this category, and the terror of travelers on the coast of Guinea, is the Guinea-worm, *Filaria medinensis* (Fig. 21), also found in other parts of Africa, and said by Mitchell to have been observed in South Carolina. It was long supposed that this filaria could introduce itself into the cellular tissue of the body directly through the skin, in the form of a microscopic embryo, but several recent observers concur in the belief that it is transmitted by means of the cyclops, a little fresh-water crustacean. This is swallowed in drinking-water, and at the end of six weeks the presence of the filaria is revealed by tumors, which later develop into open sores, caused not by the worm itself, but by the dissemination of its eggs. The filaria at last is so entirely atrophied that Prof. Jacobson, after seeing it alive on one of his patients at Copenhagen, wrote to Blainville: "This medina worm is not really a worm; it is a sheath full of eggs." In fact, all the internal organs disappear, and nothing is found in their place except the eggs and their embryos.

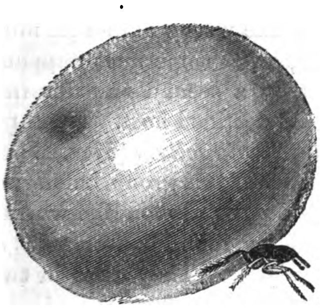


Fig. 20.—Female Chigoe.

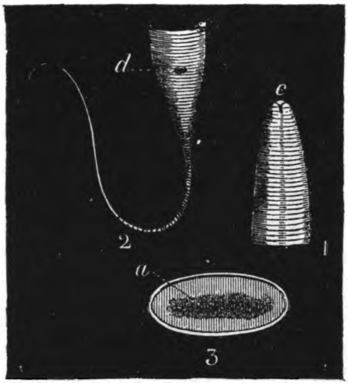
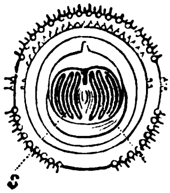


Fig. 21.—Young Filaria of Medina. 1. Anterior Extremity; *c*, Mouth. 2. Caudal Extremity; *d*. Anus. 3. Section of the Body.

The ichneumons and many other insects that lay their eggs in the living larvæ of other species, belong to a class of parasites that begin life as dependents, but that become free and self-supporting on arrival at adult age. The *Œstrus*, or gadfly of the horse (Fig. 22), is thus dependent in its early life. But, instead of making their attacks on those of their own class, the gadflies prefer to install themselves on mammals, and sometimes even on man. The eggs are received into some cavity of the body, nostrils, stomach, or a hole in the skin, where they hatch and where the larvæ feed until the adult state is reached, when they escape and afterward live in freedom.



Hinder Part.

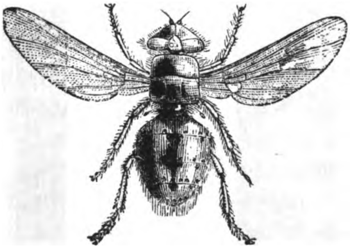
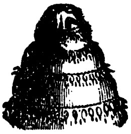


Fig. 22.—Œstrus of the Horse.



Anterior Part.

There is a large class of parasites generally known as worms, characterized by the circumstance that during their lives they undergo certain strange transformations that can only take place by the passage of the creature from one animal or host to another. The eggs are swallowed by some animal, usually a vegetable feeder, they hatch within its body, enter its tissues, and remain in a state of incomplete development until transferred to the stomach of another animal which has eaten the flesh of the first one. Here development recommences, and goes on to completion, when the process of reproduction begins. Each species of worm has its particular animals, through the agency of which these changes occur, and, if in its passage it gets off the proper track, that is, enters the wrong animal, it must either perish, or, as sometimes happens, find its way by a second transfer into the body of its destined host. The tapeworm of man, *Tænia solium* (Figs. 23 and 24), is a member of this group, belonging to the *Cestoidea*, or ribbon-like worms. These cestoids are found in all classes of vertebrate animals. They exist in two principal forms. The first or vesicular form resembles somewhat in appearance the finger of a glove partly drawn inward. In this shape they are always lodged in the midst of the flesh, or in a closed organ, surrounded by a cyst, and thus circumstanced the worm is harbored by a host which is to serve as a vehicle to introduce it into its final host. It is a parasite on a journey, and usually bears the name of *Cysticercus* (Fig. 25). In the second shape it is like a ribbon, it attains a great length, always occupies the intestine, and is mainly occupied in producing eggs, which it

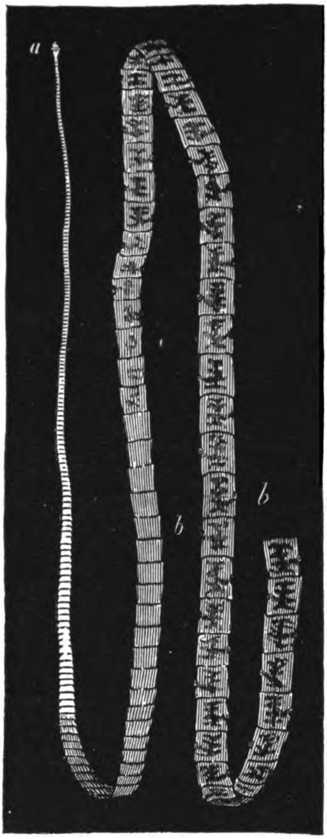


FIG. 23.—TÆNIA SOLIUM, OR SOLITARY WORM.
a, head, or scolex; *b*, tape formed of many individuals, the last of which, completely sexual, separate under the name of *Proglottides*, and represent the adult and complete animal. Each solitary worm is a colony.

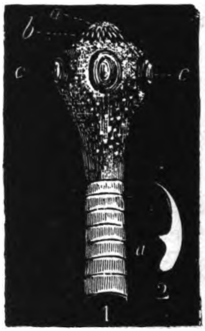


FIG. 24.—*a*, Rostellum; *b*, Crown of Hooks; *c c*, Suckers. 1. Scolex of the Tænia solium. 2. Hooks expanded; *a*, Heel of the Hook.

turns out by the million. A description of *Tænia solium*, the most common tapeworm of man, will enable us to understand all the others. Under its first, or vesicular form, this parasite comes from the flesh of the pig, where it is often found in large numbers, when the pig is said to be "measly." This condition of the pig has been attributed to damp, to feeding on acorns, to hereditary causes, to contagion, and various other influences, but none of these notions are correct. The only true cause is the introduction of the eggs of *Tænia solium* into the intestines of the pig. These eggs, or fragments of tænia containing them, are swallowed by the animal. In the gastric juice of its stomach the eggs are set at liberty, lose their shells, and there issues an embryo singularly armed. It carries in front two stylets, in the axis of the body, and on the right and left sides two other stylets, which act like fins. These embryos bore into the tissues as the mole burrows in the soil. The middle stylets are pushed forward like the snout of the insectivore, and the two lateral stylets act like the limbs, taking hold of the tissues and forcing the head forward. In this manner the embryos perforate the walls of the digestive tube, and find their way, by means of the blood or otherwise, to the organ or tissue which is to become their temporary home. When arrived at this point they surround themselves with a sheath; their stylets, no longer of use, decay; and at one of the extremities appears a crown of new hooks, quite different from the former ones, which will serve to anchor their progeny in the new host to which they are ultimately destined. This vesicular worm, or cysticercus, fully formed, and without undergoing any change, waits till its host, the pig, or that part of him which it inhabits, is eaten, and, if its life has not been destroyed on its way through the frying-pan, it wakes up in some human stomach. Once there, it instantly quits its torpid state, gets rid of its useless envel-

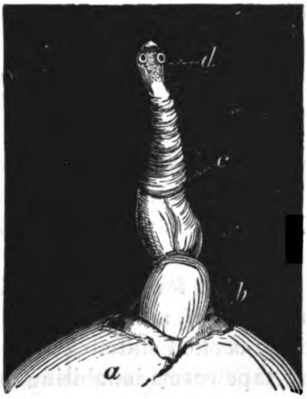


FIG. 25.—CYSTICERCUS.
a, Upper Part of the Vesicle; *b*, Place where the Vesicle is about to separate: *c*, Neck of the Worm; *d*, The Head, showing the Suckers and the Crown of Hooks.

opes, passes into the intestine, and, by means of its hooks and suckers, attaches itself to the intestinal walls, when it begins to grow with great rapidity, a length of many feet being attained in a few weeks. The part attached is the mother or head of the tænia, and until this is dislodged the worm goes on producing segments, or more properly *proglottides*, each of which is a perfect sexual being loaded with eggs. These are successively detached and escape with the evacuations, to be swallowed, perhaps, by some other pig, in whose flesh a new crop of cysticerci will soon develop. An egg of the *Tænia solium* may be swallowed by a man instead of passing into the stomach of a pig. It is hatched in his stomach precisely in the same manner, and the embryo takes up its lodging in some inclosed cavity. Some have been found in the eyeball, in the lobes of the brain, in the heart, and in the muscles. Whatever symptoms its presence may give rise to, it obviously has no chance for further progress, having selected the wrong vehicle to travel in. Man harbors not only the *Tænia solium*, but another species very similar which naturalists have only learned to distinguish from it during the last few years, the *Tænia medio-canellata.* Its cysticercus is found in beef, and is introduced when the meat is eaten in a raw or partially-cooked state. *Tænia nana* and *Tænia lata* are the names of other tapeworms inhabiting man, but both are limited in geographical distribution. The former is found only in Egypt, and the latter is confined to Russia, Poland, and Switzerland.

All these internal parasites, including the *Trichina spiralis*, which we have not space to speak of further, are introduced into the body either with the food or the drink, and a simple and effectual means of avoiding them is, to thoroughly cook the food and carefully purify the water.

PROFESSOR TYNDALL'S RECENT RESEARCHES.[1]

OBSERVATIONS ON THE OPTICAL DEPORTMENT OF THE ATMOSPHERE IN REFERENCE TO THE PHENOMENA OF PUTREFACTION AND INFECTION.

PROFESSOR TYNDALL began his paper by alluding to a former inquiry on the decomposition of vapors, and the formation of actinic clouds, by light, whereby he was led to experiments on the floating matter of the air. He referred to the experiments of Schwann, Schroeder and Dusch, Schroeder himself, to those of the illustrious French chemist Pasteur, to the reasoning of Lister and its experimental demonstration, regarding the filtering power of the lungs; from all of which he had concluded, six years ago, that the power of developing life by the air and its power of scattering light

[1] Abstract of a paper read before the Royal Society, January 18, 1876. From the *British Medical Journal.*

would be found to go hand in hand. He thought the simple expedient of examining by means of a beam of light, while the eye was kept sensitive by darkness, the character of the medium in which their experiments were conducted could not fail to be useful to workers in this field. But the method has not been much turned to account, and this year he thought it worth while to devote some time to the more complete demonstration of its utility.

He also wished to free his mind, and if possible the minds of others, from the uncertainty and confusion which now beset the doctrine of "spontaneous generation." Pasteur has pronounced it "a chimera," and expressed the undoubting conviction that this being so it is possible to remove parasitic diseases from the earth. To the medical profession, therefore, and through them to humanity at large, this question is one of the last importance. But the state of medical opinion regarding it is not satisfactory. In a recent number of the *British Medical Journal*, and in answer to the question, "In what way is contagium generated and communicated?" Messrs. Braidwood and Vacher reply that, notwithstanding "an almost incalculable amount of patient labor, the actual results obtained, especially as regards the manner of generation of contagium, have been most disappointing. Observers are even yet at variance whether these minute particles, whose discovery we have just noticed, and other disease-germs, are always produced from like bodies previously existing, or whether they do not, under certain favorable conditions, spring into existence *de novo*."

With a view to the possible diminution of the uncertainty thus described, he submitted without further preface to the Royal Society, and especially to those who study the etiology of disease, a description of the mode of procedure followed in this inquiry, and of the results to which it has led.

A number of chambers, or cases, were constructed each with a glass front, its top, bottom, back, and sides being of wood. At the back is a little door, which opens and closes on hinges, while into the sides are inserted two panes of glass, facing each other. The top is perforated in the middle by a hole two inches in diameter, closed air-tight by a sheet of India-rubber. This sheet is pierced in the middle by a pin, and through the pin-hole is passed the shank of a long pipette ending above in a small funnel. A circular tin collar, two inches in diameter, and one inch and a half high, surrounds the pipette, the space between both being packed with cotton-wool moistened by glycerine. Thus, the pipette, in moving up and down, is not only firmly clasped by the India-rubber, but it also passes through a stuffing-box of sticky cotton-wool. The width of the aperture closed by the India-rubber secures the free lateral play of the lower end of the pipette. Into two other smaller apertures in the top of the case are inserted, air-tight, the open ends of two narrow tubes, intended to connect the interior space with the atmosphere. The tubes are bent several times up and down, so as to intercept and retain the particles carried by such feeble currents as changes of temperature might cause to set in between the outer and the inner air.

The bottom of the box is pierced sometimes with a single row, sometimes with two rows of holes, in which are fixed, air-tight, large test-tubes, intended to contain the liquid to be exposed to the action of the moteless air.

On the 10th of September the first case of this description was closed. The passage of a concentrated beam across it through its two side-windows then showed the air within it to be laden with floating matter. On the 13th it was again examined. Before the beam entered, and after it quitted the case, its track was vivid in the air, but within the case it vanished. Three days of quiet sufficed to cause all the floating matter to be deposited on the sides and bottom, where it was retained by a coating of glycerine, with which the interior surface of the case had been purposely varnished. The test-tubes were then filled through the pipette, boiled for five minutes in a bath of brine or oil, and abandoned to the action of the moteless air.

During ebullition, aqueous vapor rose from the liquid into the chamber, where it was for the most part condensed, the uncondensed portion escaping, at a low temperature, through the bent tubes at the top. Before the brine was removed, little stoppers of cotton-wool were inserted in the bent tubes, lest the entrance of the air into the cooling chamber should at first be forcible enough to carry motes along with it. As soon, however, as the ambient temperature was assumed by the air within the case, the cotton-wool stoppers were removed.

We have here the oxygen, nitrogen, carbonic acid, ammonia, aqueous vapor, and all the other gaseous matters which mingle more or less with the air of a great city. We have them, moreover, "untortured" by calcination, and unchanged even by filtration or manipulation of any kind. The question now before us is, can air thus retaining all its gaseous mixtures, but self-cleansed from mechanically suspended matter, produce putrefaction? To this question, both the animal and vegetable worlds return a decided negative. Among vegetables, experiments have been made with hay, turnips, tea, coffee, hops, repeated in various ways with both acid and alkaline infusions. Among animal substances are to be mentioned many experiments with urine; while beef, mutton, hare, rabbit, kidney, liver, fowl, pheasant, grouse, haddock, sole, salmon, cod, turbot, mullet, herring, whiting, eel, oyster, have been all subjected to experiment.

The result is, that infusions of these substances exposed to the common air of the Royal Institution laboratory, maintained at a temperature of from 60° to 70° Fahr., all fell into putrefaction in the course of from two to four days. No matter where the infusions were placed, they were infallibly smitten in the end. The number of the tubes containing the infusions was multiplied till it reached six hundred, but not one of them escaped infection.

In no single instance, on the other hand, did the air which had been proved moteless by the searching beam show itself to possess the least power of producing bacterial life or the associated phenomena of putrefaction. The power of developing such life in atmospheric air and the power of scattering light are thus proved to be indissolubly united.

The sole condition necessary to cause these long dormant infusions to swarm with active life is the access of the floating matter of the air. After having remained for four months as pellucid as distilled water, the opening of the back-door of the protecting case and the consequent admission of the mote-laden air suffice in three days to render the infusion putrid and full of life.

That such life arises from mechanically suspended particles is thus reduced to ocular demonstration. Let us inquire a little more closely into the character of the particles which produce the life. Pour eau de Cologne into water, a white precipitate renders the liquid milky. Or, imitating Brücke, dissolve clean gum-mastic in alcohol, and drop it into water, the mastic is precipitated and milkiness produced. If the solution be very strong, the mastic separates in curds; but, by gradually diluting the alcoholic solution, we finally reach a point where the milkiness disappears, the liquid assuming by reflected light a bright cerulean hue. It is, in point of fact, the color of the sky, and is due to a similar cause—namely, the scattering of light by particles, small in comparison to the size of the waves of light.

When this liquid is examined by the highest microscopic power, it seems as uniform as distilled water. The mastic particles, though innumerable, entirely elude the microscope. At right angles to a luminous beam passing among the particles, they discharge perfectly polarized light. The optical deportment of the floating matter of the air proves it to be composed in part of particles of this excessively minute character. When the track of a parallel beam in dusty air is looked at horizontally through a Nicol's prism, in a direction perpendicular to the beam, the longer diagonal of the prism being vertical, a considerable portion of the light from the finer matter is extinguished. The coarser motes, on the other hand, flash out with greater force, because of the increased darkness of the space around them. It is among the finest ultra-microscopic particles, as the author shows, that matter potential as regards the development of bacterial life is to be sought.

But, though they are beyond the reach of the microscope, the existence of these particles, foreign to the atmosphere but floating in it, is as certain as if they could be felt between the fingers, or seen by the naked eye. Supposing them to augment in magnitude until they come, not only within range of the microscope, but within range of the unaided senses. Let it be assumed that our knowledge of them under these circumstances remains as defective as it is now—that we do not know whether they are germs, particles of dead organic dust, or particles of mineral matter. Suppose a vessel (say a flower-pot) to be at hand filled with nutritious earth, with which we mix our unknown particles; and that in forty-eight hours subsequently buds and blades of well-defined cresses and grasses appear above the soil. Suppose the experiment, when repeated over and over again, to yield the same unvarying result. What would be our conclusion? Should we regard those living plants as the products of dead dust, of mineral particles; or should we regard them as the offspring of living seeds? The reply is unavoidable. We should undoubtedly consider the experiment with the flower-pot as clearing up our preëxisting ignorance; we should regard the fact of their producing cresses and grasses as proof positive that the particles sown in the earth of the pot were the seeds of the plants which have grown from them. It would be simply monstrous to conclude that they had been "spontaneously generated."

This reasoning applies word for word to the development of bacteria from that floating matter which the electric beam reveals in the air, and in the absence of which no bacterial life has been generated. There seems no flaw in this reasoning; and it is so simple as to render it unlikely that the notion of bacterial life developed from dead dust can ever gain currency among the members of a great scientific profession.

A novel mode of experiment has been here pursued, and it may be urged that the conditions laid down by other investigators in this field, which have led to different results, have not been strictly adhered to. To secure accuracy in relation to these differences, the latest words of a writer on this question, who has materially influenced medical thought both in this country and in America, are quoted. "We know," he says, "that boiled turnip or hay infusions exposed to ordinary air, exposed to filtered air, to calcined air, or shut off altogether from contact with air, are more or less prone to swarm with bacteria and vibriones in the course of from two to six days." Who the "we" are who possess this knowledge is not stated. Prof. Tyndall is certainly not among the number, though he has sought anxiously for knowledge of the kind. He thus tests the statements in succession.

And, first, with regard to filtered air. A group of twelve large test-tubes was passed air-tight through a slab of wood coated with cement, in which, while hot, a heated "propagating glass," resembling a large bell-jar, was imbedded. The air within the jar was pumped out several times, air filtered through a plug of cotton-wool being permitted to supply its place. The test-tubes contained infusions of hay, turnip, beef, and mutton, three of each, twelve in all. They are as clear and cloudless at the present moment as they were upon the day of their introduction; while twelve similar tubes, prepared at the same time, in precisely the same way, and exposed to ordinary air, are clogged with mycelium, mould, and bacteria.

With regard to calcined air, a similar propagating glass was caused to cover twelve other tubes filled with the same infusion. The "glass" was exhausted and carefully filled with air, which had passed through a red-hot platinum-tube, containing a roll of red-hot platinum-gauze. Tested by the searching beam, the calcined air was found quite free from floating matter. Not a speck has invaded the limpidity of the infusions exposed to it, while twelve similar tubes, placed outside, have fallen into rottenness.

The experiments with calcined air took another form. Six years ago, it was found that, to render the laboratory air free from floating matter, it was only necessary to permit a platinum-wire heated to whiteness to act upon it for a sufficient time. Shades containing pear-juice, damson-juice, hay and turnip juice, and water of yeast, were freed from their floating matter in this way. The infusions were subsequently boiled, and permitted to remain in contact with the calcined air. They are quite clear to the present hour; while the same infusions, exposed to common air, became mouldy and rotten long ago.

It has been affirmed by other workers on this question, that turnip and hay infusions, rendered slightly alkaline, are particularly prone to exhibit the phenomena of spontaneous generation. This was not found in the present investigation to be the case. Many such infusions have been prepared, and they have continued for months without sensible alteration.

Finally, with regard to infusions wholly withdrawn from air, a group of test-tubes containing different infusions was boiled under a bell-jar filled with filtered air, and from which subsequently the air was removed as far as possible by a good air-pump. They are now as pellucid as they were at the time of their preparation more than two months ago, while a group of corresponding tubes exposed to the laboratory air has all fallen into rottenness.

There is another form of experiment on which great weight has been laid; that of hermetically-sealed tubes. On the 6th of last April, a discussion on the "Germ-Theory of Disease" was opened before the Pathological Society of London. The meeting was attended by many distinguished medical men, some of whom were profoundly influenced by the arguments, and none of whom disputed the facts brought forward against the theory on that occasion. The following important summary of these was given by Dr. Bastian: "With the view of settling these questions, therefore, we may carefully prepare an infusion from some animal tissue, be it muscle, kidney, or liver; we may place it in a flask whose neck is drawn out and narrowed in the blowpipe-flame; we may boil the fluid, seal the vessel during ebullition, and, keeping it in a warm place, may await the result, as I have often done. After a variable time, the previously-heated fluid within the hermetically-sealed flask swarms more or less plentifully with bacteria and allied organisms."

Previously to reading this statement, the author had operated upon sixteen tubes of hay and turnip infusions, and upon twenty-one tubes of beef, mackerel, eel, oyster, oatmeal, malt, and potato, hermetically sealed while boiling, not by the blow-pipe, but by the far more handy spirit-lamp flame. In no case was any appearance whatever of bacteria or allied organisms observed. The perusal of the discussion just referred to caused the author to turn again to muscle, liver, and kidney, with the view of varying and multiplying the evidence. Fowl, pheasant, snipe, partridge, plover, wild-duck, beef, mutton, heart, tongue, lungs, brains, sweetbread, tripe, the crystalline lens, vitreous humor, herring, haddock, mullet, cod-fish, sole, were all embraced in the experiments. There was neither mistake nor ambiguity about the result. One hundred and thirty-nine of the flasks operated on were exhibited, and not one of this cloud of witnesses offered the least countenance to the assertion that the liquid within flasks boiled and hermetically sealed swarms subsequently more or less plentifully with bacteria and allied organisms.

The evidence furnished by this mass of experiments that Dr. Bastian must have permitted errors either of preparation or observation to invade his work is, it is submitted, very strong. But to err is human; and, in an inquiry so difficult and fraught with such momentous issues, it is not error, but the persistence in error for dialectic ends by any of us, that is to be deprecated. The author shows by illustrations the risks of error run by himself. On October 21st, he opened the back-door of a case containing six test-tubes filled with an infusion of turnip, which had remained perfectly clear for three weeks, while three days sufficed to crowd six similar tubes exposed to mote-laden air with bacteria. With a small pipette, he took specimens from the pellucid tubes, and placed them under the microscope. One of them yielded a field of bacterial life monstrous in its copiousness. For a long time he tried vainly to detect any source of error, and was prepared to abandon the unvarying inference from all the other experiments, and to accept the result as a clear exception to what had previously appeared to be a general law. The cause of his perplexity was, however, finally traced to the tiniest speck of an infusion containing bacteria, which had clung, by capillary attraction, to the point of one of his pipettes.

Again, three tubes containing infusion of turnip, hay, and mutton, were boiled on November 2d under a bell-jar containing air so carefully filtered that the most searching examination by a concentrated beam failed to reveal a particle of floating matter. At the present time, every one of these tubes is thick with mycelium, and covered with mould. Here, surely, we have a case of spontaneous generation. Let us look to its history.

After the air has been expelled from a boiling liquid, it is difficult to continue the ebullition without "bumping." The liquid remains still for intervals, and then rises with sudden energy. It did so in the case now under consideration; and one of the tubes boiled over, the liquid overspreading the resinous surface in which the bell-jar was imbedded. For three weeks the infusions had remained perfectly clear. At the end of this time, with a view of renewing the air of the bell-jar, it was exhausted, and refilled by fresh air which had passed through a plug of cotton-wool. As the air entered, attention was attracted by two small spots of penicillium resting on the liquid which had boiled over. It was at once remarked that the experiment was a dangerous one, as the entering air would probably detach some of the spores of the penicillium, and diffuse them in the bell-jar. This was, therefore, filled very slowly, so as to render the disturbance a minimum. Next day, however, a tuft of mycelium was observed at the bottom of one of the three tubes; namely, that containing the hay-infusion. It has by this time grown so as to fill a large portion of the tube. For nearly a month longer, the two tubes containing the turnip and mutton infusions maintained their transparency unimpaired. Late in December, the mutton-infusion, which was in dangerous proximity to the outer mould, showed a tuft upon its surface. The beef-infusion continued bright and clear for nearly a fortnight longer. The recent cold weather caused me to add a third gas-stove to the two which had previously warmed the room in which the experiments are conducted. The warmth of this stove played upon one side of the bell-jar, causing currents; and, on the day after the lighting of the stove, the beef-infusion gave birth to a tuft of mycelium. In this case, the small spots of penicillium might have readily escaped attention; and, had they done so, we should have had here three cases of "spontaneous generation" far more striking than many that have been adduced.

In further illustration of the dangers incurred in this field of inquiry, the excellent paper of Dr. Roberts on "Biogenesis," in the *Philosophical Transactions* for 1874, is referred to. Dr. Roberts fills the bulb of an ordinary pipette up to about two-thirds of its capacity with the infusion to be examined. In the neck of the pipette he places a plug of dry cotton-wool. He then hermetically seals the neck, and dips the bulb into boiling water or hot oil, where he permits it to remain the requisite time. Here we have no disturbance from ebullition, and no loss by evaporation. The bulb is removed from the hot water, and permitted to cool. The sealed end of the neck is then filed off, the cotton-wool alone interposing between the infusion and the atmosphere.

The arrangement is beautiful, but it has one weak point. Cotton-wool free from germs is not to be found, and the plug employed by

Dr. Roberts infallibly contained them. In the gentle movement of the air to and fro as the temperature changed, or in any shock, jar, or motion to which the pipette might be subjected, we have certainly a cause sufficient to detach a germ now and then from the cotton-wool, which would fall into the infusion and produce its effect. Probably, also, condensation occurred at times in the neck of the pipette; the water of condensation carrying back from the cotton-wool the seeds of life. The fact of fertilization being so rare as Dr. Roberts found it to be, is a proof of the care with which his experiments were conducted. But he did find cases of fertilization after prolonged exposure to the boiling temperature; and this caused him to come to the conclusion that, under certain rare conditions, spontaneous generation may occur. He also found that an alkalized hay-infusion was so difficult to sterilize that it was capable of withstanding the boiling temperature for hours without losing its power of generating life. The most careful experiments have been made with this infusion. Dr. Roberts is certainly correct in assigning to it superior nutritive power. But, in the present inquiry, five minutes' boiling sufficed to completely sterilize the liquid.

Summing up this portion of his inquiry, the author remarks that he will hardly be charged with any desire to limit the power and potency of matter. But, holding the notions he does, it is all the more incumbent on him to affirm that, as far as inquiry has hitherto penetrated, life has never been proved to appear independently of antecedent life.

Though the author had no reason to doubt the general diffusion of germs in the atmosphere, he thought it desirable to place the point beyond question. At Down, Mr. Darwin and Mr. Francis Darwin; at High Elms, Sir John Lubbock; at Sherwood, near Tunbridge Wells, Mr. Siemens; at Pembroke Lodge, Richmond Park, Mr. Rollo Russell; at Heathfield Park, Miss Hamilton; at Greenwich Hospital, Mr. Hirst; at Kew, Dr. Hooker; and at the Crystal Palace, Mr. Price, kindly took charge of infusions, every one of which became charged with organisms. But to obtain more definite insight regarding the diffusion of atmospheric germs, a square wooden tray was penetrated with a hundred holes, into each of which was dropped a short test-tube. On October 23d, thirty of these tubes were filled with an infusion of hay, thirty-five with an infusion of turnips, and thirty-five with an infusion of beef. The tubes, with their infusions, had been previously boiled, ten at a time, in an oil-bath. One hundred circles were marked on paper, so as to form a map of the tray, and every day the state of each tube was registered upon the corresponding circle. In the following description, the term "cloudy" is used to denote the first stage of turbidity, distinct but not strong. The term "muddy" is used to denote thick turbidity.

One tube of the hundred was first singled out and rendered muddy. It belonged to the beef-group, and it was a whole day in advance of all the other tubes. The progress of putrefaction was first registered on the 26th of October. The map then taken may be thus described :

Hay.—Of the thirty specimens exposed, one had become "muddy" —the seventh in the middle row reckoning from the side of the tray nearest the stove. Six tubes remained perfectly clear between this muddy one and the stove, proving that differences of warmth may be overridden by other causes. Every one of the other tubes containing the hay-infusion showed spots of mould upon the clear liquid.

Turnip.—Four of the thirty-five tubes were very muddy, two of them being in the row next the stove, one four rows distant, and the remaining one seven rows away. Besides these, six tubes had become "clouded." There was no mould on any of the tubes.

Beef.—One tube of the thirty-five was quite muddy, in the seventh row from the stove. There were three cloudy tubes, while seven of them bore spots of mould.

As a general rule, organic infusions exposed to the air during the autumn remained for two days or more perfectly clear. Doubtless, from the first, germs fell into them, but they required time to be hatched. This period of clearness may be called the "period of latency," and, indeed, it exactly corresponds with what is understood by this term in medicine. Toward the end of the period of latency, the fall into a state of disease is comparatively sudden ; the infusion passing from perfect clearness to cloudiness more or less dense in a few hours.

Thus the tube placed in Mr. Darwin's possession was clear at 8.30 A. M. on the 19th of October, and cloudy at 4.30 P. M. Seven hours, moreover, after the first record of our tray of tubes, a marked change had occurred. It may be thus described: Instead of one, eight of the tubes containing hay-infusion had fallen into uniform muddiness. Twenty of these had produced bacterial slime, which had fallen to the bottom, every tube containing the slime being covered by mould. Three tubes only remained clear, but with mould upon their surfaces. The muddy turnip-tubes had increased from four to ten; seven tubes were clouded, while eighteen of them remained clear, with here and there a speck of mould on the surface. Of the beef, six were cloudy, and one thickly muddy, while spots of mould had formed on the majority of the remaining tubes. Fifteen hours subsequent to this observation—viz., on the morning of the 27th of October—all the tubes containing hay-infusion were smitten, though in different degrees, some of them being much more turbid than others. Of the turnip-tubes, three only remained unsmitten, and two of these had mould upon their surfaces. Only one of the thirty-five beef-infusions remained intact. A change of occupancy, moreover, had occurred in the tube which first gave way. Its muddiness remained gray for a day and a half, then it changed to bright yellow green, and it maintained this color to the end. On the 27th every tube of the hundred was smitten, the majority with uniform turbidity; some, however, with mould above and slime below, the intermediate liquid being tolerably clear. The whole process bore a striking resemblance to the propagation of a plague among a population, the attacks being successive and of different degrees of virulence.

From the irregular manner in which the tubes are attacked, we may infer that, as regards quantity, the distribution of the germs in the air is not uniform. The singling out, moreover, of one tube of the hundred by the particular bacteria that develop a green pigment shows that, as regards quality, the distribution is not uniform. The same absence of uniformity was manifested in the struggle for existence between the bacteria and penicillium. In some tubes the former were triumphant; in other tubes of the same infusion the latter were triumphant. It would seem also as if a want of uniformity as regards vital vigor prevailed. With the self-same infusion the motions of the bacteria in some tubes were exceedingly languid; while in other tubes the motions resembled a rain of projectiles, being so rapid and violent as to be followed with difficulty by the eye. Reflecting on the whole of this, the author concludes that the germs float through the atmosphere in groups or clouds, with spaces more sparsely filled between them. The touching of a nutritive fluid by a bacterial cloud would naturally have a different effect from the touching of it by the interspace between two clouds. But as, in the case of a mottled sky, the various portions of the landscape are successively visited by shade, so, in the long run, are the various tubes of our tray touched by the bacterial clouds, the final fertilization or infection of them all being the consequence. The author connects these views with the experiments of Pasteur on the non-continuity of the cause of the so-called spontaneous generation, and with other experiments of his own.[1]

The tray of tubes proved so helpful in enabling him to realize mentally the distribution of germs in the air, that on the 9th of November he exposed a second tray containing one hundred tubes filled with an infusion of mutton. On the morning of the 11th, six of the ten nearest the stove had given way to putrefaction. Three of the row most distant from the stove had yielded, while here and there over the tray particular tubes were singled out and smitten by the infection. Of the whole tray of one hundred tubes twenty-seven were either muddy or cloudy on the 11th. Thus, doubtless, in a contagious atmosphere, are individuals successively struck down. On the 12th all the tubes had given way; but the differences in their contents were extraordinary. All of them contained bacteria, some few, others in swarms. In some tubes they were slow and sickly in their motions, in some apparently dead, while in others they darted about with rampant vigor. These differences are to be referred to differences in the germinal matter, for the same infusion was presented everywhere to the air. Here also we have a picture of what occurs during an epidemic, the difference in number and energy of the bacterial swarms resembling the varying intensity of the disease. It becomes obvious from these experiments that of two individuals of the same population, exposed to a contagious atmosphere, the one may be severely, the other lightly attacked, though the two individuals may be as identical, as regards susceptibility, as two samples of one and the same mutton-infusion.

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[1] In hospital practice, the opening of a wound during the passage of a bacterial cloud would have an effect different from the opening of it in the interspace between two clouds. Certain caprices in the behavior of wounds may possibly be accounted for in this way.

The author traces still further the parallelism of these actions with the progress of infectious disease. The *Times* of January 17th contained a remarkable letter on typhoid fever, signed "M. D.," in which occurs the following statement: "In one part of it (Edinburgh), congregated together and inhabited by the lowest of the population, there are, according to the corporation return for 1874, no less than 14,319 houses or dwellings—many under one roof, on the 'flat' system—in which there are no house-connections whatever with the street-sewers, and, consequently, no water-closets. To this day, therefore, all the excrementitious and other refuse of the inhabitants is collected in pails or pans, and remains in their midst, generally in a partitioned-off corner of the living-room, until the next day, when it is taken down to the streets and emptied into corporation-carts. Drunken and vicious though the population be, herded together like sheep, and with the filth collected and kept for twenty-four hours in their very midst, it is a remarkable fact that typhoid fever and diphtheria are simply unknown in these wretched hovels."

This case has its analogue in the following experiment, which is representative of a class: On November 30th, a quantity of animal refuse, embracing beef, fish, rabbit, hare, was placed in two large test-tubes opening into a protecting chamber containing six tubes. On December 13th, when the refuse was in a state of noisome putrefaction, infusions of whiting, turnip, beef, and mutton, were placed in the other four tubes. They were boiled and abandoned to the action of the foul "sewer-gas" emitted by their two putrid companions. On Christmas-day, these infusions were limpid. The end of the pipette was then dipped into one of the putrid tubes, and a quantity of matter, comparable in smallness to the pock-lymph held on the point of a lancet, was transferred to the turnip. Its clearness was not sensibly affected at the time; but, on the 26th, it was turbid throughout. On the 27th, a speck from the infected turnip was transferred to the whiting; on the 28th, disease had taken entire possession of the whiting. To the present hour, the beef and mutton tubes remain as limpid as distilled water. Just as in the case of living men and women in Edinburgh, no amount of fetid gas had the power of propagating the plague so long as the organisms which constitute the true contagium did not gain access to the infusions.

The universal prevalence of the germinal matter of bacteria in water has been demonstrated with the utmost evidence by the experiments of Dr. Burdon Sanderson. But the germs in water are in a very different condition, as regards readiness for development, from those in air. In water they are thoroughly wetted, and ready, under the proper conditions, to pass rapidly into the finished organism. In air they are more or less desiccated, and require a period of preparation more or less long to bring them up to the starting-point of the water-germs. The rapidity of development, in an infusion infected by either a speck of liquid containing bacteria or a drop of water, is extraordinary. On January 4th, a thread of glass almost as fine as a hair was dipped into a cloudy turnip-infusion, and the tip only of the glass fibre was introduced into a large test-tube containing an infusion of red mullet; twelve hours subsequently, the perfectly pellucid liquid was cloudy throughout and full of life. A second test-tube containing the same infusion was infected with a single drop of the distilled water furnished by Messrs. Hopkin and Williams; twelve hours also sufficed to cloud the infusion thus treated. Precisely the same experiments were made with herring with the same result. At this season of the year several days' exposure to the air are needed to produce the same effect. On December 31st, a strong turnip-infusion was prepared by digesting in distilled water at a temperature of 120° Fahr. The infusion was divided between four large test-tubes, in one of which it was left unboiled, in another boiled for five minutes, and in the two remaining ones boiled, and, after cooling, infected with one drop of beef-infusion containing bacteria. In twenty-four hours, the unboiled tube and the two infected ones were cloudy; the unboiled tube being the most turbid of the three. The infusion here was peculiarly limpid after digestion; for turnip it was quite exceptional, and no amount of searching with the microscope could reveal in it at first the trace of a living bacterium; still germs were there which, suitably nourished, passed in a single day into bacterial swarms without number. Five days have not sufficed to produce an effect approximately equal to this in the boiled tube, which was uninfected but exposed to the common laboratory air.

There cannot, moreover, be a doubt that the germs in the air differ widely among themselves as regards *preparedness* for development. Some are fresh, others old; some are dry, others moist. Infected by such germs, the same infusion would require different lengths of time to develop bacterial life. This remark applies to and explains the different degrees of rapidity with which epidemic disease acts upon different people. In some, the hatching period, if it may be called such, is long, in some short, the differences depending upon the different degree of preparedness of the contagium.

The authors refers with particular satisfaction to the untiring patience, the admirable experimental skill, the veracity in thought, word, and deed, displayed throughout the inquiry by his assistant Mr. John Cottrell, who was zealously aided by his junior colleague Mr. Frank Valter.

MUSEUM GODEFFROY.

By Prof. HENRY A. WARD.

IN one of the quarters of the "old city" in Hamburg, untouched by the great fire of 1842, is a little square around which crowd tall, narrow buildings with high, pointed roofs. The quaint architecture, the flat barges in the canal, and the queer trucks with harness enough on each horse to stock a team of four, remind one of the middle ages; but the busy railway-station near by and the forest of shipping on the Elbe bearing the flags of every civilized nation tell us that this is the great commercial port of Northern Europe. Here lives Herr Cæsar Godeffroy, one of the merchant-princes of Hamburg, whose ships for half a century have been sailing over every ocean. His great wealth has been expended liberally and in many ways, as Hamburgers all bear witness. But in one unique method Herr Godeffroy has long been doing a great work for science in Europe—a work that has made his name honored among the *savants* of Germany. This is the originating and sustaining an immense museum, now called after his name; an establishment which has for its object the collection and distribution of zoölogical material, especially in the department of the invertebrates.

Herr Godeffroy had a deep love for the beautiful and rare in Nature, and his captains brought to him contributions from all seas. This plan he encouraged, and finally enjoined it upon them, furnishing them before each departure with nets, dredges, casks of alcohol, and other equipments for collecting largely wherever they went. Most of his ventures were among the South-Sea Islands, and thence came to him splendid crustaceans, mollusks, star-fishes, sea-eggs, holothuria, corals, sponges, sea-fans, and the like. The collection as received increased so overwhelmingly in quantity and variety (for this systematic and princely research had developed a marvelous wealth of new forms), that Herr Godeffroy determined to make it available to science in the fullest manner possible. So he gave up one of his warehouses, fitted it up from cellar to garret for the storage and handling of this material, and engaged curators to assort and put in shape for permanent preservation the fresh arrivals. Specialists were also enlisted to work up each department, identifying the old and describing the new. Thus some of the most distinguished German naturalists were employed in this great storehouse of Nature's wonders. Some of them even found here opportunities for wider comparison of species than in the Royal Museums at home.

In other cases material was sent to the highest authorities in the various classes. Profs. Kölliker and Spengel, for example, have worked up the mammals; Sharpe (of the British Museum) and Drs. Hartlaub, Finsch, and Gräffe, the birds; Prof. Peters, the amphibians; Dr. Günther, the fishes; Semper, the insects; Dunker, Monson, Martens, and Garret, the mollusks; Lütken, the echinoderms; Dr. Kirchenpauer, Kölliker, and Semper, the cœlenterates; and Dr. Ehlers, the protozoans.

This plan, most liberally sustained, has resulted in giving the Godeffroy Museum a high place among the cabinets of Europe for its many type-specimens and novelties. The duplicates were freely distributed to institutions of science in the Fatherland, and to many specialists beyond it. This munificence in thus aiding investigators is a theme of praise among professional zoölogists on the Continent. Many of the discoveries among the lower forms of marine life which have enriched German science during the last two decades may be credited to the Hamburg storehouse. Rarely have wealth and liberality been combined in a way more grateful to working naturalists; and never did science indirectly receive greater material benefit from one not himself an investigator. For Herr Godeffroy is a merchant, spending most of his time in his counting-room and at the Bourse, and superintending cargoes which unite Hamburg with nearly every part of the world. He visits his museum for an hour or two as a weekly recreation, looking over the beautiful forms, and hearing from his corps of workers their most noteworthy observations. It is a phenomenon too rare in America; nor is it common even in more intellectual Europe to find commerce and science thus sharing the attention of the same mind. A Berlin naturalist, who was in a position to know, told the writer that Herr Godeffroy had for many years in the early part of his enterprise expended not less than from six to eight thousand thalers each year in procuring and working up his natural history material. It was perhaps to lessen the burden of this outgo by an income, and to make the institution in part self-supporting and therefore more permanent, that in 1865 (?) the founder decided to offer for sale to European naturalists his stores of duplicate material already acquired and daily coming in. For this purpose a carefully-prepared catalogue of the Museum Godeffroy was issued, with a detailed list of the species in classified order, giving the author and locality, and the catalogue number which follows the specimen when it goes forth. This catalogue is in itself an almost exhaustive list of marine invertebrates in the regions which the Godeffroy collectors have visited; and what gives it peculiar value is its reliable indication of the locality of the specimen, coming as it does from a trained collector sending direct to the establishment. The fifth catalogue, issued in 1874, is a pamphlet of 252 pages, and notes, in close print, the name, author, locality, and price, in Prussian currency, of about 9,600 species of insects, crustaceans, mollusks, echinoderms, cœlenterates, and protözoans, besides several hundred vertebrates. Much of this invertebrate material is in alcohol. The skillful use of this, by both collector and curator, has allowed the preservation of a large series of forms which are seldom offered for sale at a natural history establishment. Such are beautiful coral-polyps and other zoöphytes, physalias, velellas, pyrosomes, salpidæ, ascidians, holothurians, arachnidæ, minute crustaceans, polyzoöans, tunicates, and many other forms of extremest interest to the student, but heretofore rarely obtainable. In a word, the Museum Godeffroy, as now conducted, is a vast storehouse of material available for the cabinets and laboratories of working naturalists and teachers of comparative zoölogy in all parts of the world. It affords a splendid opportunity to our college professors to obtain those forms so needed in a systematic course of zoölogical lectures or in rounding out the ordinal divisions in their museums.

It may be wondered that so little has been known of this Hamburg "Zoölogical Comptoir" in America. The reason is to be found in the extreme (we had almost said unfortunate) delicacy of Herr Godeffroy, who has never been willing in any way to publish this as a commercial establishment; even the catalogue gives only on one page, accidentally as it were, the facts that the objects are for sale.

The enterprise is carried on purely in the interests of scientific discovery at a yearly expense, beyond returns, of several thousand dollars. The staff of collectors, equipped and kept in the field, is very large. Among those specially engaged at present are the following:

Herr Hildebrand is dredging in the southern part of the Red Sea and along the east coast of Africa, and interior in the Somali land, a region whose fauna is little known. Herr Dämel is at work in Eastern Australia, having passed through Queensland and penetrated three hundred miles into the interior, obtaining strange forms of mollusks and that strangest of fishes—the *Ceratodus Fosteri*. Six of these fishes, about two feet long, have been secured by him, and six German museums have got these ichthyological treasures at two hundred Prussian thalers each. Also in Australia, Frau Dietrich, a second Madame Pfeiffer, for the last ten years has been traveling and collecting for the Godeffroy Museum. Her collections of insects are astonishing in the number of new forms brought to light. In the rapturous South-Sea Islands—Samoa, Viti, Pelew, Society, Marshall, and others—Herr Kubarz and Dr. Garret have resided for more than ten years, cruising from island to island and making magnificent collections of polyps, echinoderms, mollusks, and crustaceans. The observations of these educated naturalists are familiar to the readers of the "Transactions" of the German zoölogical societies. For a long time the discoveries of this large party of expert collectors were thus freely contributed to the various scientific publications of Germany and Great Britain. But in 1873 Herr Godeffroy commenced the *Journal of the Museum Godeffroy*, a thick quarto issued in four yearly parts. This journal contains the elaborate report of distinguished naturalists on the series of specimens submitted to them. Thus Milne Edwards, of the Garden of Plants at Paris, has described the crustaceans; and Lütken, of Copenhagen University, the echinoderms; and Dr. Günther, the celebrated ichthyologist of the British Museum, the fishes. The *Journal* is profusely illustrated with colored cuts, and takes high rank for its beauty and scientific value.

Such is the remarkable Museum Godeffroy. As a storehouse of material for the benefit of working naturalists it stands unique; and as an auxiliary to the purest, highest research, it is one of the signs of the times that wealth is not absorbed in material interests; that commerce counts it an honor to contribute to original investigation. May the number of such men increase, and such institutions multiply!

THE POLAR GLACIERS.

BY C. C. MERRIMAN.

THE centre of gravity of the earth is the centre of the sphere formed by the surface of the oceans; or rather, owing to the flattening of the earth at the poles, it is a point equally distant, in opposite directions, from the level of the sea. The waters, being free to move, must of necessity conform themselves to this equidistance from the gravitating centre of the whole mass. Inasmuch, then, as any plane which cuts the earth into two parts through its centre of gravity must equally divide the weight of the whole earth, it follows also that the same plane would exactly bisect the great spheroid of the oceans. In each hemisphere the sea-level in all corresponding parts would be at the same distance from this centre; and whatever land and mountains there might be above the ocean in one half would have to be counterbalanced by land, or an excess of weight of some sort, in the other half. And this counterpoising weight must itself rise above the level of the sea, unless we say that one side of the world is composed of heavier materials than the other, of which there is not the least evidence or probability.

If the plane thus dividing the earth be that of its equator, there will be found in the northern hemisphere about 44,000,000 square miles of land, and in the southern, so far as is known, about 16,000,000 square miles. Now, the great problem in physical geography is, What is there in the southern hemisphere to counterbalance this great excess of land in the northern?

Humboldt has estimated that, if the mountains and highlands of Asia were leveled down and made to fill up evenly the low places, the whole continent would have a uniform height of 1,150 feet above the sea. In like manner, South America would have a height of 1,130 feet; North America of 750 feet; and Europe of 670 feet. The average of the whole he estimates at 920 feet. Of the mainlands not included in the above—namely, Africa, Australia, the polar lands, and islands—about as much is north as south of the equator. So that we may safely estimate that there is in the northern hemisphere an excess of 28,000,000 square miles of land, of the average height above-mentioned, to be counterpoised by something yet to be found in the southern hemisphere.

If there is an excess in the quantity or bulk of water south of the equator over that north of it, then the difference of weight between this excess and so much land, which is about in the proportion of one to two and a half, must be added to the unknown quantity which we are soon to look for above the southern seas. As there is, of course, the same excess of water-surface south of the equator that there is of land-surface north of it, and as we may very safely assume that the oceans have a mean depth of at least 3,220 feet (3½ × 920) and that the southern waters average as deep as the northern, it follows that our unknown quantity is at the very least doubled by the above considerations. We have, therefore, to seek in the southern hemisphere what will balance 28,000,000 square miles of land at least 1,840 feet high.

We look over the map of the world, and down near the bottom we find some uncertain landmarks with many breaks, but on the whole tracing out very nearly the antarctic circle, and indicating that there is, covering nearly all that zone, an unexplored and scarcely discovered country. This impenetrable region is estimated to be as large as the continent of North America, about 8,000,000 square miles. A very little arithmetic will now prove the bold claim which I here make, that, even supposing the whole of this region to be land of the average continental height, there is still required over it all an average thickness of two and a half miles of solid ice to make the southern hemisphere equal the northern in weight.

This result of calculation is well confirmed by the information which all southern navigators have brought back from those most desolate and ice-bound regions. The zone of the antarctic has been encroached upon only in a small space south of the Pacific. On every other side, so far as has been discovered, mountains of ice block the way on and near the polar circle, which seems to be the great ice-barrier of the south pole. Discoverers suppose what they have looked upon to be land, but rarely have they ever seen any thing but rolling ranges of ice and snow rising higher and higher as far as the eye could reach. In the most open of the south-polar seas, Sir James Ross, in 1841, sailed 450 miles along an unbroken cliff of ice from 150 to 250 feet high, and of unknown depth beneath the water. It was one of the vast antarctic glaciers pushing down into the sea, from which some of those southern icebergs were broken off, that navigators have frequently laid down for islands, while the next sailor that voyaged that way found open water where they were charted.

Not a sign of vegetation, not an indication of thawing, has ever been discovered within or near the antarctic circle, whereas there are aboriginal races and numerous settlements of civilized communities on every side within the arctic circle. The whaleboat or the dog-sledge has traversed the arctics and found the sea-level in almost every degree of high latitude. In the south no adventurer has yet penetrated within probably 1,500 miles of the centre of greatest cold. Whence comes this great difference in the climate and ice accumulations of the two poles of the earth? It is the object of this article to inquire if in the astronomical relations of our planet there are found any sufficient causes for such differences.

The path of the earth about the sun once every year is an ellipse, with the sun in one of the foci or centres. An ellipse is a circular figure having two centres instead of one; that is, the circumference is everywhere equally distant from the two centres taken together—the sum of the two distances is always the same. Therefore, the sun being in one of these centres, the earth is nearer to it in one half of the year than in the other. At the present time the nearest approach, or the perigee, occurs about the 1st day of January; and the earth is at that time 3,200,000 miles nearer to the sun than it is on the 1st day of July.

It is a peculiar property of bodies revolving in elliptical orbits, that they travel faster when near the centre of attraction than when farther away. It follows, from the second of the three great laws of planetary motion discovered by Kepler, that the line connecting the two bodies must pass over equal areas in equal times. The earth passes through our winter portion of its orbit, that is, from autumnal to vernal equinox, in eight days less time than through the summer part of it. In the southern hemisphere, of course, the condition of things is reversed, and the winter there is eight days longer than the summer. Moreover, the sun is at its greatest distance from the earth during the long southern winter, and at its least in the short northern winter.

Of the two causes, I regard the first as of main importance. Distance from the sun, whatever theory may be, does not seem to have much effect upon climate. The southern summers, when the sun is over 3,000,000 miles nearer the earth, are said to be even some degrees cooler than the same seasons in corresponding localities of the northern hemisphere. And to take an extreme example, Mars, which is 50,000,000 miles farther from the sun than the earth is, has snow-lines about its poles which reach no nearer the equator than on our planet in corresponding seasons. But the excess or diminution of eight days, in the winters of climates which even in their warmest seasons barely balance on the thawing point of ice, is a true cause in polar conditions and differences. Considering that these days affect chiefly the period of briefest sunshine, it amounts to quite one-twentieth of the whole power of the sun on a hemisphere. This difference would not be apparent in the warm regions of the globe, where there is always an excess of heat which is carried off by evaporation and ocean-currents; but it would exert nearly its full force in polar regions which are unaffected by those influences.

It cannot be denied that it is the sun's heat which prevents the temperature of the earth from sinking to, or very near to, the absolute zero of cold, wherever in the thermometrical scale that may be. Chemists have produced a cold estimated at 257° below zero, of Fahr.[1] It is not by any means probable that this reaches the entire absence of heat. But, on the supposition that it is so, and that polar regions are unaffected by the air or water currents of the tropics, then an excess of eight winter days would lessen a polar temperature 15°, and unquestionably amount to the difference of an accumulation of ice and snow year after year, instead of the annual thawing during each summer, of the winter's increase.

This is precisely what is, or has been, taking place at the respective poles of the earth. Year after year, probably for a long period, there has been a steady accumulation of ice-material about the south pole, adding weight to that hemisphere. Then, in proportion to this increase, the centre of gravity of the earth has moved a little toward the south; and the waters, always obedient to this controlling point, have gradually gathered into the southern seas, covering the lowlands and plains of islands and continents. At the same time the waters were drawn away from the north-polar regions, uncovering lands, and leaving bays and sounds and inlets innumerable. The geography of the countries fully corresponds to these inferences. The seas of the arctics are comparatively shallow and deeply cut up, and the lands are low-lying. In the antarctics the oceans are deep and bayless, and all the mainlands and islands are precipitous and craggy, as if they were the peaks and table-lands of mountain-ranges.

It is now the question whether this state of things is a permanent arrangement—whether we of the north side are always to have the advantage of extent of territory, of fertile lands and healthful homes in middle latitudes, in short, of all that makes the rivalry of nations, and civilization a necessity. To answer this question it will be necessary to turn again to astronomy, and to study for a few moments some of its more abstruse problems.

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[1] The temperature of stellar space is estimated by Sir John Herschel and others at —239° Fahr.

In addition to the rotation of the earth on its axis once every day, and its revolution about the sun once in a year, there is also a slow, rolling motion of the equator, caused by the attraction of the sun on the excess of matter in equatorial diameters over the polar. It is precisely as when one touches the rim of a top in rapid motion: there is set up at once a slow, gyrating or tilting roll, and the upper end of the stem describes a small circle. Just so the sun lays hold of the protuberant rim of the great terrestrial top, and immediately it begins to oscillate in the long secular period of 25,868 years; while the polar axis, extended to the heavens, describes in the same length of time a small circle of 23½° radius among the northern or southern stars. This is the motion which occasions what is called the precession of the equinoxes. The plane of the earth's equator crosses the plane of its orbit; and, when the earth is at the points of junction, the days and nights are equal the world over. These two points, therefore, are the equinoxes; and the earth passes through them about the 21st days of March and September. Owing to the rolling motion of the equator, above described, these points, always in the line of intersection of the two planes, pass successively through the twelve signs or constellations, making slowly the entire circuit of the heavens. The vernal equinox, which now points to, or is on a line between, the sun and the constellation of the Fish, after about 26,000 years will have traveled the great circle of the heavens and come back again to point to the same cluster of stars which is now overhead at midnight on the 21st of March.

But the time of this revolution, so far as it affects the climate of the earth, is modified by the following circumstance: The ellipse or oblong circle in which the earth revolves about the sun is itself all the time slowly revolving. The long diameter of it—the major axis—makes a complete revolution in the heavens once in 110,000 years. Now, as this revolution is forward, or in the same direction among the constellations that the sun appears to move, while that of the equinoxes is retrograde, it follows that the extremities of the major axis, which are the perigee and the apogee, advance to meet the equinoctial points; so that the revolutions, or rather the conjunctions, of the equinoxes, which have to do with terrestrial climate, are accomplished in the shorter period of 21,000 years.

Now, all this astronomy amounts simply to this: that in the year of our Lord 1248 the earth was at its nearest approach to the sun on the 21st day of December, our winter solstice; and that in 10,500 years from that time the same thing will happen on the 21st day of July, our summer solstice. In the period comprising the first case, our winters are short and mild, and our summers long and sunny. During the cycle which shall comprise the latter case, our winters will be rigorous and our summers short. The northern hemisphere is now having its great summer. In about 10,000 years it will be in the midst of its great winter; and whatever differences there may be between the two hemispheres, owing to astronomical causes, will then be in full force against the northern.

A distinguished Scotch mathematician, Mr. James Croll,[1] has estimated that the melting of a mile in thickness of the present antarctic ice would raise the sea-level at the north pole 300 feet, and at Glasgow 280 feet. We have calculated, from data which were intended to be under-estimates in every case, that there were at least two and a half miles of average thickness in what geographers call the great ice-cupola of the south pole. If, therefore, not only this were removed, but an equal quantity of ice were deposited at the north pole, there would be a deepening of the sea at the arctic circle of 1,500 feet.

Thus it is seen that, as certainly as terrestrial revolutions continue, in the course of 10,000 years there must come an entire reversal of polar conditions. The southern waters must be drained off to make the oceans of an opposite hemisphere. New lands, enriched with the sediment of a hundred centuries, will rise up to extend the borders of the old south continents, and islands joining together, will expand into mainlands. At the same time the northern continents must be in great part submerged, and their summits and ranges become the bleak islands and the bold headlands of a tempestuous ocean. Central Asia, with its broad table-lands, may still retain the name of a continent; but, beyond a few outlying islands, there will be no Europe, and but little of North America left. The Atlantic waters will stand five hundred feet over Lake Superior, and will wash the base of the Rocky Mountains in all their length. A new Gulf Stream may again, as it must often have done before, flow up the valley of the Mississippi, returning the deltas to the prairies, and remaking the beds of the garden of the world. These are no idle or impossible fancies. Not only are they the results of rigorous calculation, but they accord perfectly with the unmistakable evidences which the ocean has left, all over our land, of its recent work and presence.

The time-honored geologist, Sir Charles Lyell, lays great stress on the quantity of land and the configurations of continents, as chiefly efficacious in the great climatic changes. But it may be pertinently asked, What becomes of his continents and configurations when the seas of one pole advance to the other, as they unquestionably do, as they cannot but do, every 10,500 years, obedient to the transfer of vast ice-weights from one end of the world to the other? On all the mountains of New England there are sea-lines at elevations of 2,000 and 3,000 feet, and Lyell himself has recorded the facts. When the ocean was that deep over Boston, there were no continents in the northern hemisphere. Undoubtedly the height and direction of mountain-ranges, the trending of sea-shores, and the course of ocean currents, have much to do with local climates. But, instead of the relative quantity or location of land and sea having any agency in producing the glacial periods, it is these periods which produce the land and the sea.

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[1] This article was written before the publication of Mr. Croll's recent work on "Climate and Time." The reference here is to an article published some years since in the *Philosophical Magazine*.

So much for the causes and conditions which pertain to the geography of the present and the future. When, now, we turn back a few of the leaves which tell of the past condition of our planet, we immediately see that the same causes have been at work in recent geological times on a much more extensive scale—in fact, that they have been the chief agents in composing and modifying the present surface of the earth outside of the tropics. Over all the northern portions of Europe, Asia, and North America, are found the unmistakable evidences of extensive and recent ice-work. Bowlders of every size, some worn and some angular, are scattered in immense quantities over all the country, on the hills, on the plains, in places where the only possible explanation is that they were lifted up, carried, and dropped, just where they are found; and the great iceberg was the carrier. The face of the rock-beds, wherever brought to view, in the valleys or on the mountains, is almost always found to be ground or polished, and, over that, grooved and furrowed with nearly parallel scratches. The Alpine glaciers are doing exactly the same work today. Erratic blocks of foreign origin, and sometimes of enormous dimensions, are frequently found perched on the very tops of hills, or stranded high up the mountain-sides; and the quarries from which they came are invariably found to the northward, sometimes fifty or even a hundred miles. It is argued that nothing but polar glaciers could thus have moved them in uniformly meridional lines. The scrapings of grounding ice-floes, the marks of ancient sea-shores, and marine relics and shells, are found at elevations of several thousand feet above the present ocean-level. There is no escaping the conclusion that the northern continents have been, in not remote ages, deeply submerged beneath an ice-laden sea; and that the entire polar and north temperate regions, extending in some places south of the fortieth parallel of latitude, have been capped with one massive covering of ice of great thickness. Precisely the same evidences are found in South America, and, according to Agassiz, even much nearer the equator than in North America. We have again to search our astronomy for causes many times more powerful than any thing we have yet found, for differences of polar temperatures.

The earth is made to revolve in an orbit drawn out of the circular form by the combined attractions of the other planets, Jupiter carrying the controlling influence. When the average of all these forces for long periods is more in one direction than in another, our planet is drawn away from the sun on that side. Now, it must occasionally happen, with the various periods of revolution of the planets, that they unite at times to produce extreme irregularities. The present difference between the nearest and farthest distance of the sun from us is 3,200,000 miles. It is found, by calculating back the planetary orbits and conjunctions, that this focal distance has been as much as 14,000,000 miles. There was, then, an excess of thirty-nine winter days during each year of the great secular winter of either pole. This exceptionally high eccentricity occurred, according to the calculations of Mr. James Croll, about 850,000 years ago. But it is now generally thought that we have no need to go back as far as that for the period of the last glacial epoch: 200,000 years ago the focal distance was 10,500,000 miles, and the winter excess twenty-eight days. This, on the supposition heretofore made of the absolute zero of cold being at least 257° below the freezing-point, would lower the mean temperature in polar regions 50° Fahr., and would unquestionably extend the permanent ice-limits far into the temperate zone. From that time, down to 70,000 years ago, the eccentricity was continually from two to four times greater than now. Since about 70,000 years ago, it has been nearly all the time less than at present. Thus it may fairly be concluded that the great glacial period of the Post-tertiary era came to an end with the fourth secular winter in the past, or B. C. 67,000.

This is a very interesting date to us of the genus *homo;* for it must have been about this time, according to all accounts, that our forefathers made their appearance on the earth. Man, with the long-haired mammoth, the woolly rhinoceros, the huge cave-bear, the great horned reindeer, and numerous other species now extinct, followed close upon the retreating ice-fields of the bowlder period. Our primeval ancestors were a race of hunters, and they subsisted on the most abundant and magnificent game that the world has ever seen. They lived in caves or under projecting ledges, and with only flint-headed weapons contested their lives and homes with savage beasts. They cracked the bones of animals for their marrow, or crushed them in stone mortars for the fats and the juices which they contained. It was the lingering carnivorous instinct to gnaw the bones of their prey. They had fires at their funeral feasts, but there is little evidence of their indulging often in the luxury of cooked meats. It was a rude life, and a hard struggle they must have had for it; but their history is read in the drift-beds and cave-deposits of Europe, as plainly as if there had been an Herodotus to write it.

The effect and bearing of the great ice periods on geological work and time will be further considered in a second article in continuation of this.

MODERN PHILOSOPHICAL BIOLOGY.

By Dr. E. CAZELLES.

TRANSLATED FROM THE FRENCH BY J. FITZGERALD, A. M.

II.

NOT all matter is capable of performing vital acts. Those substances alone possess this property which, owing to their peculiar composition, readily undergo molecular changes; that is to say, whose parts are grouped in very unstable equilibrium, and which are always ready to form other combinations. This state of instability is the result of complex combinations of six simple bodies, which at common temperatures have a very weak affinity for one another, but a strong affinity for elements outside of these combinations. Of the six, four, namely oxygen, hydrogen, carbon, and nitrogen, enter into these combinations in large proportions, while of the other two, namely sulphur and phosphorus, only a few atoms enter; and these latter elements are so readily oxidized that their presence increases the instability of the compound. Besides, the atoms of these simple bodies, though occurring in identical proportions, may be grouped according to different modes of aggregation (isomerism and polymerism), and the organic compounds which they make up stand midway between liquids and solids; their molecules are highly inconstant, whence result two well-known properties: the plasticity of organic matter, and its permeability to other substances. These properties are further causes of instability, inasmuch as they expose the organic substances to a number of disturbing influences. Thus, organic matter is not only subject to decomposition by light and heat, but also by the direct or indirect chemical action of bodies entering it, or acting on it from without. In such cases the effect of the disturbance is to cause the organic substance to pass from a state of relative instability to one of relative stability, or even to the state of compounds the most stable in the organic world.

At the same time that it undergoes the action of these external forces—and among external forces we include those developed in organized beings, but applied to other tissues than those producing them—at the same time that under the action of these external forces organic matter suffers decomposition, it becomes the scene of notable reactions. Even very inconsiderable changes in the external forces, which serve as its conditions, produce in it new molecular arrangements which offer a contrast, in their extent and importance, to the comparative insignificance of their cause. These new arrangements, being succeeded by more stable combinations, in turn bring about a disengagement of a great amount of force, in passing from a less stable to a more stable equilibrium. The atoms of the organic substance lose part of their latent motion, which is manifested externally under the form of heat, electricity, light, nervous force, or mechanical motion, according to circumstances. Be the cause which produces these changes necessary or not, they are, of necessity, accompanied by a disengagement of force; and we can affirm of any force whatever expended by an organ of a living being, that it is the equivalent of a force acting from without upon that being. This is a consequence of the law of the persistence of force, and it may be presented under two forms: First, in order that a certain amount of force may be expended by a living being, there must have taken place, within that being, a transformation, by decomposition, of a quantity of organic substance capable of holding that force in the latent state; and, secondly, there can be no transformation of organic matter holding force in the latent state, without an expenditure of force which shall manifest itself in some shape externally.

In general terms, what we have to consider in living things is, first, a substance of special composition, and then expenditures of force by that substance; and this, too, is what we have in general terms to consider, in non-living things. The former are distinguished from the latter by the fact that the changes which constitute their history are heterogeneous; that they form many series which are simultaneous, correlative, held together by a tie of mutual dependence, the result being a high degree of complexity, a phenomenon belonging to one series having antecedents and consequents in other simultaneous series; and above all, that these changes form clearly-defined combinations. This *ensemble* of characteristics not only enables us to distinguish living from non-living things, but also to distinguish between living things themselves and to class them according to their *degree of life.* Thus a thing stands all the higher in the vital scale in proportion as, from the beginning to the end of its vital manifestations, it exhibits a larger number of successive and simultaneous changes, and as these changes are more heterogeneous and more closely linked together, and in more definite relations to one another. Between the lowest animals, rhizopods, planaria, etc., and the highest, the birds of prey, mammalia, carnivora, man, there is an enormous dissimilarity; still the definition applies to them all, and serves to define the difference which separates them, as also the difference of the numerous species lying between these extremes of the animal series.

Though this definition is a good one, inasmuch as it applies to all living things, and to them alone, nevertheless it is defective in that it omits the most distinctive peculiarity, namely, the element known as activity, in other words, those operations whereby living beings adapt themselves to their conditions of life. The definition should include the general relations of the living thing to its environment. The environment, too, has its successive and correlative changes which, though very diverse, present no definite combinations. Its composition, no doubt, is definite, and equally so its properties; but they are variable, and its variations alter the relations of the environment to the living being. To all changes of the environment there are corresponding changes in the living being, otherwise it would perish. These changes, which follow the laws of vital changes, inasmuch as they are in a definite combination, constitute the activity of the animal; the more numerous and frequent they are, the more active is the life and the higher the rank of the living being in the scale of life. The degree of correspondence between the living thing and its environment is also its degree of life, inasmuch as in effect it connotes an increase in the number and in the mutual dependence of the vital changes which constitute life. A perfect correspondence would imply a perfect life. If to all changes of the environment there were opposed, as a counterbalance, changes in the living thing, natural death would be no more, nor death by disease or by accident, all of which are signs of a lack of correspondence.[1]

A definition of life which possesses these characters, and which expresses in a general formula the law of the changes of structure, and of the changes of function accompanying them; that is to say, which expresses the heterogeneity, the coördination, and the ever-increasing mutual dependence of these changes; and which at the same time expresses the ever-increasing correspondence which attaches them to the changes of the environment by an operation of equilibration—such a definition makes life to be an evolution, a succession of states of unstable equilibrium tending to perfect equilibrium; not only an evolution of the individual from the moment when it became more heterogeneous by the differentiation of parts and functions, but also an evolution of the *ensemble* of living beings, from the first appearance of life in its least differentiated form up to the highest degree of complexity in structure and function.

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[1] We must here point out an erroneous statement made by Claude Bernard. In his article on the "Definition of Life" (*Revue des Deux Mondes*, 15 Mai, 1875, p. 345), this eminent physiologist offers as a complete definition of life a portion of Spencer's definition, as found in the "Principles of Biology." "The following definition," says he, "is proposed by Herbert Spencer: 'Life is the definite combination of heterogeneous changes, both simultaneous and successive.'" And he goes on to say: "Under this abstract form the English philosopher would specially indicate the idea of evolution and of succession observed in vital phenomena." If M. Claude Bernard had made this quotation from the "Principles of Biology" itself, he would have read immediately after this passage the following words: "This is a formula which fails to call up an adequate conception. And it fails from omitting the most distinctive peculiarity—the peculiarity of which we have the most familiar experience, and with which our notion of life is, more than with any other, associated. It remains now to supplement the definition by the addition of this peculiarity" (p. 71). Those who have studied Mr. Spencer's writings know how cautiously he sets about making a definition. He completes a formula, first expressed in very general terms, by the successive addition of essential characters, and for each of these characters he makes a minute analysis. Thus, having given as a preliminary result the formula quoted by M. Claude Bernard, Mr. Spencer adds that it needs to be completed, and a few pages further on (p. 74) he adds these words: "In correspondence with external coexistences and sequences." Again (p. 80), he writes: "The broadest and most complete definition of life will be—The continuous adjustment of internal relations to external relations." It is evident that M. Claude Bernard did not derive from the "Principles of Biology" the definition he quotes, and which he condemns. But ought he not to have taken it from that work?

If life is an evolution, of what is it an evolution? If the question refers to an individual of any given species, the answer is easily given, for we can study the history of its life from the germinal cell to the period of its full development, and to the end of its life. But if the question refers to the *ensemble* of living Nature, only the middle portion of which is known to us, and the beginning of which we have no idea of save in imagination, then the reply must be only an hypothesis. We find groups differing from one another by their respective degrees of vital evolution, and we regard them as being, not as it were links of one chain, but rather the result of an evolution which has taken different directions owing to different circumstances. Hence we can admit only one starting-point, though the goals are many. The divergent lines which we find in the development of the forms of living things, in the history of life, warrant our supposing the starting-point to be one, and at this point the evolution hypothesis must place the formation of primordial organic matter, whose reactions with its environment present the first crude examples of vital function.

The hypothesis which accounts for the production of life by the spontaneous generation of a complete organism from simple protoplasm is irreconcilable with evolution; this would suppose something more than an evolution, in fact a *beginning* in the absolute sense, an enormous hiatus between the causes and their supposed effects. But on the theory of evolution we can conceive of another mode of formation. It is possible that even now, under existing cosmical conditions, organic matter is produced; but it is more probable that it was formed in an epoch when the cosmical forces now known to us, especially heat and light, had on earth a greater intensity than at present. The first types must have been more simple, less definite, less fixed in form and structure, than the lowest rhizopods of our day. Indeed, they must have been more nearly allied to protoplasm than even Haeckel's *Protogenes;* and, before evolution could derive from these types our present infusoria, ages and ages must have elapsed. Strictly speaking, we cannot call the first living thing an organism at all, in the true sense of that term; it is stretching the meaning of words to speak of types in connection with beings whose form must have been perfectly unstable, and whose organization had no structure.

Of this quasi-organism we have merely a symbolic conception, formed by combining two positive, empiric elements, viz., transformations of substances strictly evolutive, such as we see in the laboratory of the chemist, where organic matter goes through a series of gradual modifications by which it is adapted to new artificial conditions; and, on the other hand, facts observed in the lowest orders of animals by the biologist. We conceive that, in the primordial world, as now in the laboratory, higher types of organic substance were formed at the expense of lower types, and that gradually, after repeated reactions and under favorable conditions, they resulted in organizable protoplasm, a substance which is very susceptible of modification. Protein, as we know, may exist in upward of one thousand isomeric forms, and, by combination with itself and with other substances, it yields products still more complex, and in countless numbers. Hence we can easily conceive how, under the conditions of heat and light then existing on earth, and with the aqueous, mineral, and atmospheric environment of that epoch, protein may have undergone metamorphoses without end. Under conditions which we can conceive as possible, though we may not be able to define them exactly, products may have been evolved fitted to exhibit the rudimentary vital reactions. In this way we fill up the chasm which divides the positive chemical facts of the higher organic combinations from the biological phenomena of the lower forms of life.

But another hypothesis is still necessary. "When we come down to the substances out of which living bodies are formed, we find groups and sub-groups of manifold and divergent compounds, the units of which are large, heterogeneous, and unstable in a high degree. Why should we suppose that these combinations must stand still at the complex colloids which enter into the composition of organic matter? Is it not more probable that, in addition to these colloids, there are developed by a higher combination atoms still more heterogeneous and compounds still more numerous? If colloids are unstable, extremely modifiable by very slight incident forces, and incapable of assuming the equilibrated form of crystallization, then *a fortiori* these new organic atoms are unstable, very modifiable, and of many different species." They would surpass protein in instability and plasticity as much as protein surpasses organic matter. Furthermore, these atoms would possess one fundamental property, without which no explanation is possible in biology, viz., the property of arranging themselves in certain forms peculiar to the various groups to which they belong—a property but little understood, though its existence is unquestionable. We call it *polarity*, for want of a better term, to indicate the power of manifesting actions in a certain fixed direction. These atoms we denominate *physiological units*. They are developed in every living thing, differentiating themselves from one another in different organisms by the same causes which differentiate the organisms themselves, and in this way acquiring a diversity which corresponds to that of the creature they constitute by their aggregation. They follow, step by step, in their modifications the modifications of the aggregate to which they belong. They undergo the influence of the environment, though indirectly, through this aggregate. Their modifications are new directions, amplitudes of new vibrations, which place them in equilibrium with the forces which the *ensemble* of the aggregate, as modified by the environment, brings to bear upon them. These modifications endure as long as equilibrium endures, and are ever transmitted to the new units which spring from the former ones, until, on the equilibrium being disturbed, a new breaking-up of the existing relations necessitates others.

The hypothesis of physiological units is a necessity, not only in order to fill up the gap which separates the highest products of organic chemistry from those irreducible elements revealed by the microscope which we call morphological elements, but also in order to furnish a substratum for the positive property which serves to account for the great facts of biology, and to refer them, by formulæ expressed in terms of mechanics, to first principles.

Let us now consider the great facts of biology.

The *growth* of an organism is an operation essentially like the growth of a crystal. "Around a plant there exist certain elements that are like the elements which form its substance; and its increase of size is effected by continually integrating those surrounding like elements with itself. Nor does the animal fundamentally differ in this respect from the plant or the crystal. Its food is a portion of the environing matter that contains some compound atoms like some of the compound atoms constituting its tissues; and, either through simple imbibition or through digestion, the animal eventually integrates with itself units like those of which it is built up, and leaves behind unlike units."

Organic growth differs from inorganic in this, that it has limits. All conditions remaining the same (a proviso that must always be made in biology), and the quantity of integrated substance not varying, we find that, by the principle of the persistence of force, the growth of the living being must depend on the expenditure. The only portion of the integrated substance that can serve for growth is the unexpended residue, the excess of nutrition over expenditure—a quantity which is essentially variable, and which transfers its variations to the growth, limiting it and diminishing it more or less rapidly from the moment when the body of the living thing has attained its full development. Experience shows that the limit of growth is fixed for those organisms which have large expenditure, and that for those which have hardly any expenditure this limit gradually recedes; of this the crocodile is an instance. But there is another element which must be taken into account, namely, that the definitive volume of an organism, being the sum of its initial volume and of its successive increments, must depend upon the initial volume. The definitive volume depends also on the organization, which enables the living thing to assimilate substances in large quantity and to dispose of an amount of nutrition in excess of the expenditure, just as a large capital, while it gives the means of undertaking great enterprises, at the same time yields increased profits.

The integration by an organism of substances homologous with its own has for its effect a segregation which increases the difference between the organism and the environment, and at the same time makes this difference stable. While the organism is being integrated, at the expense of the environment, by deriving from it special materials, each organ is being integrated at the expense of the organism, from which it derives, as from an environment, its special materials. Like the organism, each organ diverges more and more, by a gradual segregation, from the organs around about it. The organic units which constitute it attract other units with the same polarity, diffused throughout the fluids. This is not always the case, and homologous units do not always exist ready made in the nutrient fluid. More generally the organic units find in the fluids only the elements necessary for the production of homologous units, and segregation is perfected by a phenomenon of the nature of a genesis. Still in this case, as in the preceding, the result is a more perfect differentiation of the parts of the organism, an increase of heterogeneity, and augmentation of the distinction between the different parts, and ultimately the formation of a structure and of an actual organism. This result is called *development*.

Expressed in general terms, development is the transition from a state of incoherent homogeneity to a state of coherent and definite heterogeneity; from a state wherein the parts are all alike, or rather, where there are no distinct parts, to a state wherein there are parts clearly defined, with fixed forms and attributes. The bud of a plant consists of a hemispherical or subconical projection which, at its apex especially, is made up of a transparent mass of cells not yet organized into tissues. This mass grows owing to the rapid multiplication of the cells, lengthens, sends forth other similar projections having a like homogeneous structure; from this come leaves. As the branch develops, the cells, which at first were identical, assume different characters, till at last they lose all resemblance to one another. The same thing takes place in man. His arm is at first simply a little budding prominence on one side of the embryo, consisting of simple cells without any signs of arrangement. Soon there appear vessels, and later the cartilaginous parts from which are produced the bones, the gelatin-like bands which afterward are transformed into muscles, etc. In the individual we see the first phase of existence characterized by a state of homogeneity wherein nothing is distinct, and we follow step by step the gradations of its transition to a greater complexity, and to states characterized by increasing distinction of parts, as their dissimilarity becomes greater. And what is true of the individual animal or plant is equally true of the whole organic world. Baer's law would lead us to suppose that the organic world has developed like the individual; that, starting from homogeneity, it has resulted in heterogeneity. In the early stages of their existence, all organisms are alike in most of their characters; somewhat later their structure resembles that found at the corresponding period in a smaller group; at each subsequent stage the organism acquires traits which distinguish the developing embryo from one after another of the groups which before it resembled; till finally the class of organisms which it resembles includes only the species to which the embryo belongs. Thus, in the process of differentiation, the embryo first acquires those characters which determine the *sub-kingdom* to which it belongs, then the *class*, then the *genus*, finally the *species*. In the series of organisms we should thus find a succession of states like those which constitute the history of the individual, with this difference, that in the individual we can make out the link which connects the primitive homogeneity with the final heterogeneity, while in the series of organisms all we can do is to connect, with a considerable degree of probability, the hypothetical starting-point with the positive goal.

Side by side with heterogeneity and distinction of parts in the structure, we have a correlative result of this same segregative operation, viz., differentiation, which tends to produce heterogeneity and distinction of functions. The expenditure of the force that is stored up in the shape of materials takes place through the parts of the organism, however little heterogeneous these may be supposed to be, and this force is in fact for the parts an incident force which, by the law of the multiplication of effects, must break up in the process of differentiation, when applied to heterogeneous parts. The functions are simply the variously-modified forms assumed by the forces disengaged by the organism as they traverse specialized parts; and, the more diversified the organs, the more diversified are the functions they manifest. Of these some may be denominated static, inasmuch as they serve only to withstand external forces by equilibrating them; such, for example, are the functions of the woody axis in plants and of the skeleton in the vertebrata; others may be called dynamic, as producing motion and giving it direction; such, for example, are the functions of the circulatory apparatus and its belongings in both kingdoms of the organic world, and of the muscular apparatus in animals.

Like structure, function obeys the law of evolution; it proceeds from the homogeneous, the undefined, the incoherent, to the heterogeneous, the definite, the coherent. Like structure, function proceeds from the simple to the composite, from the general to the special. An important corollary results from this law—one that settles the dispute which has so long divided physiologists upon the question as to which precedes the other, function or structure. If the starting-point be homogeneity, and if the transition from a structureless to a structural state is a phenomenon of vital action, then vital action precedes structure. Life is a system of internal actions adapted to equilibrate external actions; actions are the substance of life, its form comes from structure. Hence action must of necessity precede the fixation of the structure, which produces the adaptation and gives definite form to the function. From first to last, function is the determining cause of structure. But in justice to those who maintain the precedence of structure, it must be added that function, which, as we hold, is anterior to structure, nevertheless, regarded as an activity modified and different from what it was, assumes its differential, distinguishing characters only in proportion as the adaptation becomes perfect, and as equilibrium is established between that portion of internal reaction which it represents and the external action which it withstands.

At first there are only two functions, corresponding to the structural distinctions of endoderm and ectoderm, viz., the functions of accumulation and of expenditure of force. In proportion as each of the apparatus and each of the corresponding functions become differentiated and subdivided into specialized parts, a third function appears and takes root; at first this is a very simple affair, and it employs an ill-developed apparatus, but gradually it becomes more complex, and ultimately, in the higher animals, is divided into very definitely specialized parts. This is the circulatory apparatus, which performs those operations whereby materials containing latent force are distributed throughout the organism.

But differentiation is not the only change produced in the organism. The functions, as they multiply and are better defined, combine, become dependent on each other, are *integrated.* Labor is divided, as they say in political economy, but it is also centralized, and coördinated. Alongside of division of labor we have coöperation: an organ does not work for itself alone; it has a special function, but this function serves to facilitate, or even to render possible, the special function of some other organ.

As the formation of an organ depends on the function, so the growth of an organ depends on the growth of the function, and when once produced it is maintained only when the increase of function persists. And not only its growth, but also its development (including the differentiation of structure which accompanies it), depends on the development of the function, or, in other words, on the differentiation of the reactions of the organism to the forces of the environment.

We shall all the better understand the mechanism of the adaptation and of the modifications produced in one another by function and structure, if we consider what must of necessity occur when an augmentation of function in an organ answers to an augmentation of the demand for work made by the external conditions. In virtue of the law of universal rhythm, the result of excess of function is excess of wear, and consequent relative impotence of the organ. Thus excess of function in the organ A cannot go on forever unless the losses are constantly made good, the wear compensated, its power renovated; and this cannot be without an augmentation of function in one or more organs, B, C, D, etc., on the activity of which its own activity depends. The increase of function in these organs once established by a definite structure, the organ A not only can preserve its increase of structure and function, but it has now a firmer basis for growing still more, for producing another excess of function, and for going farther in the same direction than otherwise it could have gone. But adaptive modifications have a limit, and it is always near at hand, though it slowly retreats from generation to generation. This we learn from the mechanism of adaptation. As the function of an organ cannot be permanently increased save on condition that the functions of those organs on the action of which it depends have gained a permanent increment, and as they in turn are conditioned on a permanent increment in the functions of other organs, it is plain that there is needed nothing short of a reconstruction of the whole organism upon a plan which shall insure normal provision for the organ that is subject to an excess of function, and in which this excess of function shall be in fact a normal process. If equilibrium be disturbed at one point, it is reëstablished only by propagating its own disturbance to all the internal equilibria; and, in order that it may itself endure, it must not be disturbed by a perturbation of reaction from within; the internal equilibria must be restored at the expense of the forces developed by the nutrition, and must be fixed by modifications of structure.

So long as this rearrangement of the internal equilibria remains unconsolidated by a reconstruction of the general structure, so long will the equilibrium produced by the adaptive modification, at the point affected by the initial disturbance, remain instable. And if, now, the disturbing conditions from without cease to exist, then the new structure, no longer sustained, so to speak, by an excess of temporary function, and receiving from the auxiliary organs, which are not yet adapted to this service, no permanent excess of function, can only furnish the same amount of action which it furnished originally. Little by little the imperfectly modified parts return to their original functions, and the whole scheme of adaptation comes to naught. Thus we see that, in virtue of the general laws set forth in the "First Principles," an adaptive change must quickly find a term beyond which it cannot progress save slowly—a fact which explains the apparent fixity of species, or the inconsiderableness of such deviations from a type as can occur during the periods over which our observations extend. It is plain that a modifying cause, the action of which persists only for a short time, can produce only a transient modification; that the complexity of the internal equilibria and their reciprocal dependence constitute the one great obstacle to the permanent change of structures and functions; that a disturbing influence, even though it were to extend to many generations, can only modify a race superficially; and, finally, that, the instant that this cause ceases to be, the race resumes, slowly but surely, its original characters.

In fact, the environment is ever changing, and in the enormous cycles of changes in the conditions surrounding organic life upon the earth the same conditions have never occurred a second time. Organisms must follow this movement of variation; they must be ever undergoing a process of adaptation, in order to be in equilibrium with the altered conditions around them. In this necessity for adaptation we recognize a consequence of our first principles. The state of homogeneity must give way to a state of heterogeneity: a species must be ever growing more and more varied in its forms; old species must be ever breaking up into new. If at one time a species consisted of individuals alike in all respects, the action of the various forces of the environment would soon put an end to this uniformity; at the same time, however, leaving tokens of relationship. But let us go further, and suppose the conditions to be still more profoundly altered, owing, for instance, to a climatic perturbation of the habitat, or to an emigration of the species into other habitats; in that case there will be different sets of conditions, and the groups of individuals will resemble one another, or be unlike, according to the likeness or unlikeness of the conditions. The connection between changes in the conditions, changes in function, and changes in structure, is a consequence of the persistence of force.

The law of heredity, which is antagonistic to the law of variation, may also be traced back to our first principles. This law represents the element of fixity in the domain of life. All the organisms of a given type are descended from organisms of the same type. If we consider heredity in a succession of organisms, it appears to be inexplicable. Many still deny the existence of heredity, and explain the resemblance of the child to its parentage by a special intervention of the creative power of Nature. But, if we compare the heredity of the individual with certain phenomena occurring in the individual, for example, the repair of tissues, the reproduction of worn-out or lost parts—a process which in some animals goes so far as to reproduce highly-complex organs or groups of organs (for instance, in lizards, the reproduction of feet and tail; the reconstruction of the fresh-water hydra; the restoration of the plant *Begonia phyllomaniaca* from a fragment of its leaf)—we shall perceive that there exists a tendency to reproduce like products, and that the two orders of phenomena are related. We must suppose them both to be due to the tendency of the physiological units of an organism to arrange themselves in the form proper to that organism. But we need not recognize in this tendency any such mystic entity as an *Archæus* or a *vital* *principle.* Sound philosophy should discredit all such fanciful ideas. The tendency merely signifies that these polarities, being complexes of the physiological units, can find equilibrium only in the form of the adult organism to which they belong. To this equilibrium they tend, not only by an internal impulsion, but also under the combined action of external forces: the latter represent the force which arranges the units in a new order, and the former the direction in which this force is exerted. Now, the cells which go to reproduce an organism are in a state of unstable equilibrium and of minimum heterogeneity: but they are not indifferent substances; they are the vehicles of physiological units derived from the parents, and they follow only the tendency impressed upon them by their polarities. The same is to be said of the elements of the plasma from which a tissue or an organ is reproduced. Thus we see that the resemblance of an organism to the organisms from which it is sprung is the result of the tendencies proper to the physiological units which have come from the parents.

In the fecundated germ there are two groups of physiological units, presenting in their structures slight differences, so that by their fundamental resemblance they conspire to form an organism of the species to which the parents belong, and by their differences they give to this organism traits peculiar to each of the two parents. In this way, simultaneously with transmission of generic and specific characters, we have transmission of those which are peculiar to the individual. Further, we see that characters due to variations called accidental or spontaneous, because we are unable to assign their true cause, must also be transmitted as a tendency of the physiological units, provided this character has gained in the individual such a degree of stability as henceforth to find its place in that individual's state of equilibrium. The action of the surrounding conditions will determine whether the tendency of the physiological units is to be realized or frustrated. The tendency of the physiological units expresses an internal equilibrium, and hence heredity is a consequence of our first principles.

One character of living things is the faculty of reproducing themselves, i. e., of emitting parts of themselves which develop into perfect individuals. This property, in all respects analogous to that which reproduces tissues, differs from the latter only as regards the production of new individuals, or only parts of the same individual. There is an analogy between the operation of generation and that of repair, but there is also a difference. In repair the new products are aggregated around the same axis as the old, whereas in generation the new product soon becomes itself the axis around which the increments of nutrition group themselves. In reality, the contrasts are in excess of the analogies; generation is at bottom an operation of disintegration. This is very well seen in those low organisms which produce new generations by fission, and abdicate their individuality in favor of a greater or less number of new individualities. It is also to be seen in those organisms on whose surface a new organism is formed by the process of budding. Here the disintegration is perfect, or nearly so, but in the higher organisms the disintegration affects only an insignificant portion of the parent.

Why this special disintegration? Biology can give no answer, unless we suppose that the genesis of individuals belongs as a genus to a class of facts including all the phenomena of general disintegration which attend growth, and which mark the gradual decline of the organism. This supposition finds its warrant in the fact that, as a general rule, reproduction does not take place until growth and structural development approach their term, when the molecular forces of the physiological units find themselves in equilibrium with the forces of the organism as a whole, and with the forces from without. Disintegration would now set in, or, to speak more exactly, disintegration would now begin to show an excess over integration, for, ever since the earliest vital phenomenon, disintegration has constantly accompanied integration. Among the various modes in which the decline of the organism is gradually brought about, there is one which resembles all the others, inasmuch as it constitutes a loss to the individual, but which differs from them in that it gives rise to new organisms. In a large number of cases among individuals of the lower orders of organisms, units combined in a certain group, and carrying away with them, as we have seen, their own proper tendency to find the equilibrium of their forces in arrangements similar to those in which they were originally integrated, become detached, and form the centre of a new integration. But in a very large number of organisms, and in all higher organisms of both the organic kingdoms, reproduction takes place by the mixture of two products, the one germinal, the other spermatic, coming from slightly different physiological units. In virtue of a property found in the simplest organic elements, and still more markedly present in the complex organic elements of living things, the mixture of substances which differ little from one another gives rise to products that are less stable than their constituent elements. Accordingly, the result of this mixture, namely, the fecundated germ, is farther from the state of equilibrium than were the units emitted by each of the parents, in the shape of germinal and spermatic cells. The faint tendency which existed in each of these groups to produce evolutional phenomena is intensified with the instability of the mixture. From this we may infer, if not the impossibility, at least the difficulty of an agamic genesis, and the necessity of a genesis by concurrence of different sexes. This conclusion, derived from the law of equilibrium, which itself flows from the law of persistence of force, seems to be hardly in agreement with facts, since unquestionably there exists such a thing as agamic genesis. But agamo-genesis is not habitual in organisms of very simple structure, which exhibit the first steps in evolution, and in which the absence of highly-specialized tissues shows that integration still possesses its full intensity, and is far removed from equilibrium. Besides, those more complex organisms which exhibit the phenomenon of agamo-genesis, from time to time reproduce by way of gamo-genesis. After a series of agamic generations, the units of the organism will find themselves in an attitude approaching that of mutual equilibrium. The groups of units emitted as germs will no longer be able to assume arrangements which shall give them the form proper to their species, and agamo-genesis will be impossible, or very difficult. The series would come to an end did not sexual generation intervene periodically, restoring a state of instability, which gives back to the organism the power of evolution. Another conclusion, which at first sight appears to contradict the facts, is this, that an organism needs, in order to reproduction, the concurrence of another organism differing slightly from it. This is true of the higher organisms; but lower down in the animal scale, and in most phanerogamous plants, hermaphrodism is apparently the rule. But, not to speak of the fact that most frequently fecundation takes place in monœcious organisms by the intervention of another individual, so that such authors as Huxley and Darwin regard this intervention as the law of reproduction, the hypothesis which we maintain affords an explanation of hermaphrodism in those exceptional cases where it appears to exist beyond question. On the same principles which account for the variable results of the union of near kindred, we can understand how, in the case of hermaphrodites, there may exist simultaneously groups of physiological units coming from each parent, keeping their proper tendencies, which find only partial equilibrium, permitting one or other side to be in excess, and there undergoing the operation of segregation, which produces groups so differentiated that fruitful germs result from their mixture.

Considered in the light of this hypothesis, generation appears as a fact of disaggregation, occurring in an organism in process of equilibration: as a fact of disaggregation, which ever renews the evolution of the species, and which retards its equilibrium by multiplying the conditions under which the species may, under the influence of the incident forces of the environment, undergo a more perfect elaboration, the result of which shall be a better adaptation of the organism to its surroundings. Generation is in fact antagonistic to equilibrium, but this antagonism is only temporary, and causes the organic evolution to obey the law of universal rhythm.

[*To be continued.*]

THE CHARACTER OF MODERN KNOWLEDGE.[1]

By J. L. W. THUDICHUM, M. D.

THE science of the present age is distinguishable from the learning of past ages by many important features. By these it has indeed somewhat altered the sense originally attributable to its name, and science has become a word of greater precision, and therefore of a less broad significance than what may be termed mere knowledge. This is so little understood, that when lately a great statesman and orator met some of his constituents in a southeastern suburb of this metropolis, he informed them, among other things, that science was merely another term for knowledge. Even if it had been so originally, and the Latin word *scientia* had been merely the equivalent of the Saxon word knowledge, it would have to be admitted that the relations have changed by one of those conventions which are silent and convenient. We hold that the systemic enunciation of mere knowledge is doctrine; that science is a kind of knowledge, but that not all knowledge is science. Science is that kind of knowledge the correctness and truth of which can be proved by evidence convincing to all healthy understandings. Science is a series of potentialized axioms, which when once mastered are as evident as the simple axioms in mathematics, which are said to be so self-evident as to require no proof. By this definition a very large amount of human knowledge or doctrine is at once excluded from the domain of science. The learning of past ages was mainly imitative, little observant of new phenomena. Those ages had too much work on hand, first in the development of their languages, in which they used imitations countless in number, next in the shape of securing the conditions of social life in the form of communities and states. But even where these may be said to have been secured, e. g., at the height of power of the Roman Empire, science was not developed, and it may be said that this absence of scientific treatment of the common problems of life has been one of the principal causes of the downfall of that, and of many other states. Famines, epidemics, among men and cattle, and wars, are made possible or necessary only by the absence or faulty application of the principles taught by science. Science, by teaching that, and how, these evils are to be avoided, has a field in this generation, of which the past had not even a distant conception. Imitative learning shows itself mainly as art, buildings, sculptures, paintings; all the mass of temples and gods which fill the world's history and imagination are of this kind. There is no science about a Greek or Egyptian temple, simply because there is no value in it; it does not satisfy, to our present mode of thinking, one single demand of the understanding. There is no science about our present homes, or how could they get filled with sewer-gas, be devoid of arrangements for ventilation, and have square chimneys. Architecture, so called, is not a science, but an imitative art, beautiful but blundering. Manufactures have, too often, been carried on with great disregard of science, with the result that either empiricism was, for the time, successful enough, or that the manufacture went simply out of existence. It is the same with commerce. These arts have worked by tradition, by prescription, by precedent. They all wait for an infusion of the scientific method, the method of principle based upon natural laws immutable and indestructible. While not often scientific themselves, these branches of human knowledge, administering all the time, for a consideration of gain to be paid by the recipient, to important human wants, have yet indirectly advanced science by either finding and bringing, or by producing some of its materials.

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[1] Introductory remarks to a course of lectures on the "Life and Labors of Prof. Liebig.

Antiquity, then, possessed no science, except alone the results of meditation, which have been termed metaphysics, and which, if allowed to include ethics and logic, have no doubt attained in the treatment of philosophers a high degree of development. The contemplation of Nature, however, in its inorganic and organized shape, and of the causes determining all motion and development, was not greatly developed. The power of distinction, the mother of all knowledge, was not applied to all things, and consequently they termed a process such as fire an element, and allowed some all-pervading material to exist under the name of the quintessence. Bodies fell to the ground because they possessed weight; but that the falling was a reciprocal action between the earth and the body falling upon it escaped their observation, and was only found by science.

Mere observation is not science, but only the beginning of science. When a person, sitting in the railway-train, beholds the traveling shadow, he makes an observation. He begins a scientific inquiry, when he asks whether the shadow travels as quickly as the train, so as to be in a line falling from the sun past the train or whether the shadow is not a little later. If once the question has arisen, it is immaterial where it is solved, whether upon the railway-train, or the satellites of Jupiter—the question must lead to the idea that light requires time for traveling; exact science determines this time by measuring space. Science began its development with the elucidation of celestial phenomena, and became astronomy, or the doctrine of the laws according to which heavenly bodies move. Copernicus is from this point of view the father, the creator of science. Kepler, Galileo, and Newton, reduced the observations of these phenomena to expressions of regularity which we call laws. The method once found was applied to other branches of knowledge; then arose the physiology of the animal and vegetable world, based upon anatomy as a science, Harvey made physiology a science, and so on in all branches of knowledge.

Now, let us see what was the method by which these results were obtained. Meditation had of course the inciting share, but furnished no materials. Observation accumulated the materials of which reflection might weave a tissue, the test was experiment. If from a knowledge of conditions a result can be predicted, then there is certainty. Such certainty is science; it consists of observation, meditation, knowledge of conditions, knowledge of their results, and therefore of the connection between results and causes; these being regular, immutable, within the time accessible to our perceptions, and coercing everything under their sway, are called natural laws.

Of science, it is allowed that no part comes out of the human brain alone, not even the ideas of God and Immortality, which Kant claimed as innate ideas, while allowing all others to be the result of observation and reflection. The celebrated joke, that, if an Englishman and a German were asked to produce a camel each, the Teuton would evolve one out of his inner consciousness while the Briton would produce a camel of flesh and bone, is a good satire upon innate ideas. Science did not progress until it rejected all innate ideas or phantasies, and applied itself deeply to its proper methods, to observation, to meditation on the correlation of forces, and to experiment. Work, work, and again work, were the three main features of its success. The search for the philosopher's stone, for the medicine that should make young, healthy, happy, and rich, was also work, enormous in amount and extension, but it was not based upon observation. It left results which science gathered, the main result being that we cannot prolong our lives forward, but we can, as Kopp has beautifully said, prolong them backward indefinitely, and see the changes of enormous spaces of time pass before our admiring eyes and minds.

There are three kinds of history, that of our planetary system in the theory of Laplace, that of our earth in geology, that of living things in the theory of Darwin. No serious person doubts now that the teachings of geology deserve the title of an exact science, and that compared to its coercing character upon the mind of man the convictions derived from written history are feeble in the extreme, and all contradictory writings, however old, mere nullities. The youngest of the sciences or branch of science is chemistry, founded by Lavoisier and Dalton; developed by thousands of clear heads and nimble hands, it has in half a century become a recognized power in the affairs of man. It has materially improved his estate, and enlarged his mind to conceptions of an elevating nature; it has become a ready test of his reasoning and working power. It has become the handmaid of almost all the elder sisters of astronomy, teaching the composition of distant stars; of geology, teaching the composition and changes of strata and minerals; of physiology, vegetable and animal, teaching about food, nutrition, growth, changes, death, and decay; of the healing art, teaching the nature of evils in the shape of disease, and the means of curing or mitigating them. This science, too, was developed by work, work, work—physical and mental; its ways were often rugged; its endeavors misapprehended, opposed, suppressed. And the great men whose names are inscribed upon the roll of its principal promotors will be considered by posterity as benefactors akin to Hercules, removing evils, establishing the good and true. If we cannot now inscribe their names and likenesses among the stars, and transfer them to an Olympian abode, yet we can honor them by admiring their works and lessons, by sharing and continuing their work, by, as it were, living their lives with them over again, and thus prolong their memory forward while we prolong our own in the inverse direction. We ought to honor them out of gratitude no less than out of the desire to benefit continuously man's estate. Such feelings have been instrumental in the cases of those who described the greatness of your Davy, of your Faraday. Such feelings shall now be the guiding principle in the consideration of the life, works, and philosophy of Justus Liebig. But I must beg you to understand that I shall proceed by a severe process, that of analysis, for nothing less than the results of analysis of work done can establish as proved what many feel as a sentiment. You will understand both the censure and the acclamation of what we will call the world; you will see the necessity for a reform in the philosophy of many of us; you will see how the life and labor of one man have produced vast applications and industries, improved or created a large commerce, and enhanced or engendered art; how they have soothed the pain and anguish of hundreds of thousands under the most severe trials of human organization, and how they have left a growing harvest in the hearts and minds of men all over the world.

THE RELATIONS OF SEX TO CRIME.[1]

BY ELY VAN DE WARKER, M. D.

SEXUAL cerebration may here and there be seen coming to the surface, amid the complex array of circumstance and causes which affects woman's criminal career. If I am correct in the use of the term, and it surely has the merit of expressing the idea designed to be conveyed by it, we may perceive two forms of sexual mental action, one normal and the other abnormal. Its action in the normal phase may be seen in favoring or obstructing her career in crime, in relation to particular offenses; while its abnormal manifestations may be perceived in certain crimes, existing as a direct outcome of its presence. It must be observed that sexual cerebration in its relation to crime is not confined in its operation to the female sex. Its influence on men may be observed in many of the crimes in which they exceed their usual ratio of excess over women. Man's tendency to belligerency evidently accounts in a measure for his great excess in the crimes of murder and assassination. Attempts have been made to explain this by the frequency of drunkenness, and the street brawls which it leads to among men; but, when we take into consideration the fact that the ratio of the sexes for drunkenness in England is, 1 woman to 1.49 men (Quetelet), we perceive that this cause can but act to a very limited extent. The sexual mental tendency of man to the wager of battle, his physical strength, the almost unlimited opportunities afforded by the greater range of his activities, enable man to exceed his usual ratio of excess over woman in these two crimes. Crimes against property, such as robbery from the person or highway robbery, also offer evidence of the innate cerebral traits of the male. In this offense man stands almost alone. It requires for its successful perpetration bravery and daring. These are qualities belonging peculiarly to men. In view of the intensity of feeling which attends all discussion of matters in which women are concerned, either socially or sexually, I think it better to qualify the last sentence, by calling the attention of the reader to the very proper distinction between moral and physical courage. The first exists as the result of intellectual qualities, education, and moral training; the last is purely a phase of sexual cerebration. Some of the most beautiful examples of moral courage are constantly offered by women. It is the possession of physical courage which is requisite to the commission of the crime alluded to, and not its higher prototype, moral courage. This form of sexual cerebration in the male is the coefficient of belligerency in the perpetration of many crimes, and united to physical strength is, aside from opportunity, capable of explaining many of the circumstances attending man's excess over woman as a criminal.

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[1] Argument continued from January MONTHLY.

The action of sexual cerebration in its normal expression, as affecting the relation of men to crime, has been traced far enough to demonstrate its important influence. Its operation in men is more easily detected than in women. Man's career as a criminal is attended by fewer complicating conditions. By the broader field of his activities, he is directly exposed to criminal influences, while woman is hedged in by the circumstances of her position. She lives in an atmosphere of restraining influences, each one of which tends to obscure the effect of the subtile yet potent sexual mental traits which characterize her as a woman. The extent to which woman conforms to a common mental type may be more surely measured by contrasting her as a criminal with man in his relation to crime, than by studying her alone in her usual social relations. Crime reveals to us some of the primeval tendencies of society. By crime, notwithstanding all the varied results of civilization—a scion, as it were, grafted upon the parent trunk—humanity is wedded to its original savagism. Certain sociologists of the religious school teach that crime is the outcome of civilization, that it increases or decreases in proportion to the extent and quality of religious teaching; but an examination of the criminal returns of various peoples shows that crime exists at nearly a fixed ratio without regard to religion, be it what it may. Some forms of crime are, beyond doubt, increased by the artificial needs of society in its civilized form, infanticide and abortion, for example; yet even these crimes prevail universally among the most primitive races. Civilization has not modified the crime, it has simply changed the motive. With the tendency to crime existing at the ultimate fibres of man's psychical life, the expression of sexual cerebration in the criminal conduct of women assumes a naturalism called forth by no other social relation. As I have separately examined the matter of sexual mental types in a former article, all that is necessary here is, to apply the conclusions there reached to woman's tendency to crime.

The crime of poisoning, with its remarkable ratio, has been used a few pages back to illustrate the influence of the physical factor. It was called the weapon of weakness. This weakness is twofold, physical and mental. Women possess moral courage, but not physical. Timidity, a shrinking from bodily danger, a fear of combat, each an analogue of the other, appear as mental traits in the average woman. Here is an offense gauged to woman's mental and physical aptitudes. By means of poison, a fatal blow may be given by the weakest arm without the fear of combat, or of physical hurt. To a mind with criminal tendencies, hampered by the reflex consciousness of weakness, the security, the secrecy, are charming. The result is that, as a poisoner, woman nearly equals man. This equality among the lists of crime nowhere else appears except in offenses against the currency, a crime also remarkable for its secrecy, and freedom from personal encounter during its perpetration. If a further extension of the statistics of crime against the currency confirms the ratio of the sexes deducible from Mr. Neison's tables, it will amount to nearly a demonstration of the fact here shadowed forth, that woman tends to equal man as a criminal in those crimes which require neither physical courage nor strength as conditions of their perpetration. The crime of vagrancy is the only exception that offers itself, and which loses its force as an exception under the law of criminal analogies. From the crime of poisoning, the climax of the criminal tendency, downward through the lighter shades of offense, this phase of sexual cerebration may be detected. If it were possible to give to woman the physical strength of man with this mental trait existing in its present force as a sexual characteristic, I doubt if it would alter essentially the known ratio of the sexes for murder and the wounding of strangers—9 to 100. I venture this prediction merely for the purpose of illustrating the potency of this mental factor touching woman's criminal relations. In robbery from the person, although the enormous disproportion in the ratio is in a measure explained by differences in physical strength, yet there remains much of this excess of men to be explained by other means. That which remains to be explained by means other than that of sexual differences of physical strength may be stated in this way: The ratio of the strength of the two sexes being fixed at 16 to 26, and the ratio for crimes in general against property being 26 to 100, we nevertheless find that for the crime mentioned the ratio is reduced to 8 in 100. Here is a difference in ratio between two classes of the same division of crime of 18 to 100. Evidently, it is too largely in excess of the ratio of strength of the sexes, to be entirely accounted for by that alone. This phase of sexual cerebration, together with woman's social conditions, is competent to explain the differences remaining unaccounted for. The crime of self-murder also brings out quite distinctly the action of this mental trait in women. An examination of the methods of self-destruction reveals sexual peculiarities. Men prefer cutting instruments and fire-arms, while women select poison, and hanging and drowning (Quetelet). A collection of nearly five thousand cases of suicide, by M. Brierre de Boismont,[1] reveals the fact that hanging occurs more frequently among women than men, by a large percentage. It will be noticed that women select those modes of suicidal death which take the matter out of their own hands. They offer a surety for their fainting spirits by closing the avenue of escape behind them. However painful may be the death they seek, after the fatal draught, the fall, or the plunge, all voluntary power of escape is beyond their reach. Is it not from the consciousness that lack of physical courage, or timidity, would involuntarily cause them to escape from the pangs of death, that they select a method of destruction which after the painless first step renders such a return impossible? Cortes, who knew the temper of his men, burned his ships upon the shore; and in the same way women assure themselves of the impossibility of return ere they attempt suicide.

The influence of the excess of the emotional life in women over men, upon their criminal career, is not so marked as that of the psychical traits just considered. I stated in a former chapter that there was evidence which rendered it probable that those emotions or passions which serve as the incentives to crime approached in intensity the same mental conditions in man. In that portion of these contributions devoted to "Sexual Cerebration," emphasis was given to the fact that the emotional life of woman exceeded that of man. At this point in the study we can give this practical significance. The emotions offer vulnerable places in woman's moral armor. These mental sexual attributes which give such grace and beauty to woman's character cannot exist except at the expense of rigidity and sternness of mind. Through all Nature may be found analogies which give probability to this. Nature, in her forms of fixity and power, is massive and rugged in her outlines; it is only in her phases of changing, transient life, that she assumes lines of beauty, delicacy of shape, and clothes her proportions in the subtile harmonies of color. I do not deny woman firmness of character; but surely, whatever firmness she possesses, it is not by reason of her emotions that it exists. Nor do I wish to be understood as saying that any excess of emotion woman may possess over man is necessarily the cause of inherent weakness of character; but, the idea I intend to convey is, that excessive development of the emotions affords a way of approach to the firmer characteristics of her mind of those exciting causes of crime, which, without these avenues, must act with less force as criminal factors. The evidence of this lies in the tendency of woman to exceed in a marked manner her ratio to crimes in general against the person when exposed to the action of causes which act more or less directly upon her emotional life. Women perpetrate crimes, involving human life, more frequently within the circle of their domestic relations than men (Quetelet). In view of this fact, let us inquire as to the probable motives which cause women to exceed men in crimes against persons within this restricted area. If we were to explain it as the result simply of the great opportunity women have of perpetrating crime in the family, it leads to the conclusion that women's criminal tendencies exceed those of men under favorable opportunities, and which men in the same relation possess to an equal extent. This we know is a wrong conclusion; therefore, while we must allow the great facilities afforded to women a certain value as a factor in this excess, yet it is not adequate to explain the fact. It is in the family that woman finds a field for the free action of her emotional life. It is as an outcome from these emotions that the family exists; it is through these emotions that the most deadly wounds may be inflicted upon her morality and self-respect. In the majority of cases, if through her error, or that of others, the family is a failure, the woman of the family is a failure also. In this can be found the strongest argument for encouraging woman to become expert in some form of labor, so as to enlarge the field of her self-dependence, that she may be able to secure safety for herself in the trying hour of domestic misfortune. While the family is called into existence by reason of the most potent sexual mental traits, and finds its strength and permanency in a temperate use and even balance of the emotions, it may become the source of the most active criminal impulses. Conjugal incontinence, jealousy, a misplaced love, may create the most deadly strife in the family circle. Especially is this true if the criminal tendency exists latent, as an inherited taint, in the members of the family, and ready to be kindled into life by emotions which, in others, free from inherited vice, would not pass beyond the control of the moral faculties. Man, whose activities are less confined within the area of domestic life, is more able than woman to resist the action of the emotions. Another cause, which comparatively releases man from the criminal tendencies which grow out of a violated emotional life, is the weaker hold these emotions have upon his conscious life. These are my reasons for concluding that this excess over men, as a criminal against persons, within these limits, is the result of the more active development of the emotions in women.

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[1] "Recherches Medico-Légale sur Suicide," Paris, 1860.

Considering that, in the purely sexual relations of men and women, the male is the active and the female the passive one, the ratio between the sexes for the crime of adultery offers additional confirmation of the foregoing. For this purpose I shall select the statistics of M. de Marsangy, than whom none can be selected more favorably disposed to women. This author places the ratio for men at 528, and women at 472 to 1,000.[1] As these were cases which came under the notice of the public prosecutor, it is reasonable to suppose that the circumstances attending them were in both sexes of a flagrant character, so that possibly the usual attitude of the sexes toward each other in this offense was reversed. These ratios render the assumption safe that it is in crimes which grow out of the acute and excessive emotional life of women that they tend to equal men as criminals. If it were any tendency to crime, growing out of sexual mental traits possessed more equally in common than the emotions, which causes the tendency to equality above referred to, it would be reasonable to expect to find the sexes occasionally approaching a common ratio in crimes against property, and which could be traced to the same mental traits. But a careful survey of the field shows this not to be so. Woman's delicacy and keenness of emotional life, when their undue exercise or unbalanced proportions seek expression in the criminal act, lead to crimes against persons, not against property. Even incendiarism, so commonly practised by men from motives of revenge, is but seldom attempted by women. The enmities of women are never general. They are roused by particular persons and special acts; hence their revenge takes an individual direction, not against the property, but against the person of the enemy. The wounding of parents, and parricide, exceeding by so large a ratio all other acts of violence against the person, I believe can be explained in no other way. Admitting, as I have already done, that the great opportunity afforded of making attempts upon the persons of parents has some value as a factor, yet we must bear in mind that, from the nature of their domestic life, women have opportunities equally as great of inflicting injury upon others. It follows that opportunity as it affects parents must be given exceptional value, in order to account for their being the objects of criminal attempts on the part of daughters, over that of other persons holding a domestic relation. The ratio of crimes against parents also makes it very probable tnat the purely sexual emotions are not particularly important as factors in the grave class of crime now under consideration. So far as it relates to parents, these emotions may be excluded. Other emotions must in parricide be called into action. But, in poisoning and crimes affecting others beyond parental relation, I believe the purely sexual emotion is the main ingredient in the motive. M. Quetelet states that adultery, domestic quarrels, and jealousy, cause nearly an equal number of poisoning in both sexes; but in murder the number of women by the husbands exceeds the number of husbands by the wives. In poisoning, with the ratio of 91 to 100, for all motives and against unspecified persons, we perceive that when the crime is brought within the domestic circle and against persons bearing a very close relation to women and narrowed down to these motives, all differences between the sexes disappear. This is brought out in order to make clear the fact that women are not worse than men, but that under conditions favorable to their more restricted sphere of activities, and from motives operating in the direction of their peculiar psychical traits, they will equal men in the perpetration of those crimes suited to their strength. Crime, as it relates to men and is perpetrated by them, conforms in an equal manner to their physical and mental characteristics, and exists in a ratio with the sphere of their activities. While a difference of morality may exist between the sexes, it is not equal to explain the constantly varying ratios of the sexes to crime. Whatever the differences of morality may be, it is not sufficient to create any difference in the tendency to crime, when the crime conforms to the conditions just stated. The abnormal action of mental sexual traits is more often met with among women than among men. M. Prosper Despine assigns great importance to the moral perversions which accompany the hysterical tendency in women, and regards it as one of the marked characteristics of sex in crime. Hysteria in its myriad forms, when it disturbs cerebral function, appears to be a perversion of the emotional faculties. An offense committed during an attack of hysterical insanity is not of course a crime, as I am here studying it; but it is a grave question, to what extent may the criminal habit grow out of the perversion of morals which may attend the hysterical state of mind? In the course of two years' acquaintance with criminal female convicts, I became impressed with the fact that nearly every one of them gave evidence of possessing hysterical tendencies. In connection with this tendency, another significant fact was observed—the power to control the expression of the feelings and emotions was much less in them than in the average woman. Women who are liable to attacks of hysterical perversion of the emotions are usually under the direct influence of the diseased action but a short time, so that the possibility of criminal attempts at such times is comparatively limited. It is not therefore the presence of an actual attack of hysteria which promotes the tendency to crime; but the impaired control over the desires and emotions which coexists with the hysterical temperament may lead to this. Which is the cause, and which the effect, it is difficult to assert. From the prevalence of hysteria among prostitutes—a class who habitually permit the desires and emotions to pass beyond healthy control of the will—I infer that this precedes the actual attack of the disease. In some cases, however, hysteria results from organic derangement, usually of the sexual organs, and then the lack of emotional control may be a secondary instead of primary condition. The criminal resultant, in my experience, is confined to crimes against property, false accusation, and infanticide. It rarely leads to the more serious crimes against persons, for the reason that the wrongs of the hysterical are fancied rather than real, which disappear with the usually prompt return of judgment.

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[1] *Loc. cit.*, table, p. 147.

The following history of a false accusation reveals the defective control over the feelings and the perversion of the sexual emotions which coexist with the hysterical tendency: Esther was a young convict, about twenty years old, committed for a term of years to the Onondaga penitentiary for a second offense of stealing. She married very young, and lived with her husband but a short time. Her occupation was that of a domestic, and when not employed always went to her home, which was respectable. She gave considerable trouble in the shops, by her moody and disobedient ways, and would often refuse her food, and was then taciturn and desponding. Her cell was situated near the centre of the block, on the second gallery, and was lined with pictures cut from the illustrated newspapers. The collection was remarkable from being made up of the pictures of men and women, some of them neatly framed with straws. A cross, made of the thin shavings of wood used to light cigars with, was prominent among the decorations. She gave me considerable trouble with her great variety of fancied ailments, and I believe the girl actually believed in her diseases. The keepers believed her to be a "beat," a most unfortunate reputation for one to earn while under the discipline of a penitentiary. Esther startled the prison officials one morning, by charging the night-watch—a most estimable young man—with visiting her cell at night. From the method of locking the cells, this appeared to the officers nearly an impossible thing for the watchman to do. A careful examination of the inmates of the adjoining cells failed to elicit any confirming evidence; yet Esther persisted in her charge, to the great distress of the young man. As Leander nightly buffeted with the waves of the Hellespont for the love of Hero, it was thought possible that love might contend not less successfully with patent locks and prison-bars. It was therefore considered the safest course to remove the young man. When Esther was informed of the effect of her charge, she at once retracted. Now, the motive of this accusation constitutes the essence of the story. Esther loved the night-watch. She had for months fed her passion on the sight of the young man. The class of people to whom this woman belonged do not possess imaginations sufficiently acute to invest love with any charm. Their relation with an object of love is emotional; their only gratification is possession. As possession was impossible, there was yet a way to establish a link between herself and wished-for lover. She brought a false charge against a man who had never spoken a word to her in his life. She took pride in the fact that his name was associated with hers in a manner most congenial to her emotions. It was the nearest approach to possession possible. This girl was very properly placed upon bread and water for her offense; but I am quite confident that such a false accusation, except for purposes of revenge, is only possible in a woman of hysterical tendencies, and in whom the emotions have passed beyond the inhibitory power of the moral sense. A false accusation of this nature is not a very rare one for women to make, and it is usually accompanied by two noteworthy circumstances—the woman is generally very young, and the man in some way nearly unattainable by the accuser.

To the liability of insanity to accompany the hereditary transmission of crime, I have already made sufficient reference; but the class described above are not insane, they simply lack the normal equipoise between the different faculties of mind. As to how far this may affect the relations of women to the different classes of crime we have no means of forming an opinion. As it is a mental characteristic more frequently observed in women than men, it is reasonable to suppose that it has some influence. Its effect upon the votaries of the social evil is, however, very great, and careful study will be made of it in the chapter devoted to woman's crime against her sex.

Particular stress has been laid by other authors upon the fact that the great excess of men over women in certain crimes against the person, as murder and assassination, was the result of intoxication and brawling to which men are addicted. If this is one of the factors of such excess, it will be interesting to know it. If this is any explanation, it follows that one sex must so greatly exceed the other in the matter of intoxication and disorderly conduct, as it is termed by the police courts, as not only to include the ratio between the sexes for crimes mentioned, but also to include the chances of no such result following, as but a small percentage of debauches and brawls results in either murder or assassination. As it is in great cities that men addicted to disorderly conduct are mostly to be found, and as there also they are more liable to terminate in crimes against the person, I shall select statistics from cities touching upon this matter, bearing in mind, however, that a perfect contrast between the sexes cannot be secured, as the offenses under analysis include drunkenness and fighting in the male, and both those, with the addition of prostitution, in the female. The ratios are based upon the statistics furnished by the report of the Commissioners of Public Charities and Correction. For the period covered by the reports, 90 per centum of those arrested for disorderly conduct and intoxication were women.[1] It becomes evident at once that the excess of men over women, in crimes against the person, cannot to any extent be accounted for by the proneness of men to intoxication and disorderly conduct, and which we perceive does not so greatly exceed that of women. Instead of searching among accidental qualities for the causes of this difference, rather ought we to examine the mental and physical qualities which exist inherently in man. From the same source we may gain an idea which bears in another direction upon this matter. The ratio of drunkenness and disorderly conduct to total crime, for the sexes separately, furnishes nearly positive proof that it has but a restricted influence upon the tendency to crime in general. Thus, these offenses furnish 41 per centum of the total crime committed by men; while, of the total crime committed by women, 80 per centum is of the same nature. While the number of drunk and disorderly among men is larger by a small excess than the number of women so addicted, yet women considered by themselves exhibit twice the tendency to these offenses that men do. Here, the sex which affords the least measure of total crime gives the largest ratio, relatively to her own sex, of those offenses which are so generally supposed to underlie the criminal tendency. The explanation I would offer of this rather unexpected result is, that intoxication and disorderly conduct are offenses closely allied to vagrancy and its analogue, prostitution; that this class represents the effete among men and women who gravitate into vice from total lack of vitality and energy to keep themselves up to the level of the average. The active criminal requires mental and physical energy in order to pursue his course. Any of the conditions of life which depress the physical powers and deplete mental energy tend to remove those with criminal tendencies from the order of active criminals, and place them among those addicted to the minor degrees of crime. While habitual intoxication and disorderly conduct lead to the lighter offenses against property, the more serious crimes against property and persons are comparatively unaffected by these causes, either among men or women.

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CAROLINE LUCRETIA HERSCHEL.

By ELIZA A. YOUMANS.

MOST people in this country have heard of Miss Caroline Herschel the astronomer. Without knowing much about her, she has been vaguely regarded by the public as a profound scientific genius, the strong-minded peer and coadjutor of her brother, the illustrious Sir William Herschel. It is supposed that she rose above the narrow sphere of woman's usual domestic life, and spent her time in studying the universe and making astronomical discoveries. She has been often cited, in the recent discussions of the woman question, as an illustration of the intellectual equality of the sexes and as demonstrating to the world what woman is capable of doing in science when she gets a fair opportunity.

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[1] "Reports of the Prison Association of New York," Tables "C," "D," "E," "F," 1867, and Tables "C," "D," "E," "F," "G," "H," 1871 and 1873.

Miss Herschel's memoirs have just appeared, made up mostly from her diary and correspondence, edited by Mrs. John Herschel. In this interesting volume we get a view of her real character, and discover that the notions generally accepted are widely mistaken. We learn from her diary and letters that, while she was a thrifty and interested housekeeper, she had neither the taste, the ambition, nor the mental qualities, that would have insured distinction in an independent intellectual career. It is seen that she became an astronomer by accident, as it were, and through the strength of her affection rather than of her intellect. When she found that her brother had resolved to take her as his assistant in his astronomic labors, it made her miserable for a time; and he chose her instead of either of his brothers, not because of her brilliant mind, but on account of her persevering devotion to his interests and her dexterity and readiness in doing an assistant's work.

The lesson of this book is very important to ambitious girls who despise domestic concerns, and long for an "intellectual" career. Her science, as such, gave Miss Herschel no great enjoyment; her happiness came from her womanly devotion to her brother's ambitious work; and the book will be found painfully interesting as it discloses the suffering she also experienced as the penalty of this unselfish devotion.

Miss Herschel lived to the great age of ninety-seven years and ten months, and retained her faculties bright to the last. We give a portrait, taken from the biography, which represents her at the age of ninety-two. In the following sketch we shall let her speak for herself, as far as practicable, as nothing can exceed the graphic simplicity of her diary. But, as she was a German, and did not begin to study English till she went to England, at the age of twenty-two, there are defects in her writing, for which the reader will make due allowance.

Caroline Lucretia Herschel was the eighth of a family of ten children, four of whom died in childhood. Her father was band-master in the regiment of Guards at Hanover, and all his children had musical genius. He took great pains to cultivate his sons in music, and sent them to the garrison school for their routine education. As they grew up they all became musicians and joined the regiment band. At Dettingen, in 1743, the father was wounded and left all night in a wet furrow, and he had ever after an impaired constitution and an asthmatical affection. This event cast a shadow upon the family, and when Caroline was born, in 1750, in the gloomy period of the Seven Years' War, the mother's temper seems to have been already warped by trouble.

Her turn of mind was practical and plodding, while the father was intellectual and aspiring. It is abundantly evident that Caroline had a bitter and desolate childhood. Expressions of affection or regard from her relatives were very rare in her experience, while her own sympathies had a most precocious development. It is said that when only three years old she was deeply concerned about family troubles.

Her only sister, the oldest child of the family, was married to a musician named Griesbach. Jacob, the eldest brother, was organist at the garrison church; and William, four years younger, was already remarkable for his splendid talents, apart from music. In the following passage from her diary we have a picture of the family at this time:

> "My brothers were often introduced as solo performers and assistants in the orchestra of the court, and I remember that I was frequently prevented from going to sleep by the lively criticism on music on coming from a concert, or conversations on philosophical subjects, which lasted frequently till morning, in which my father was a lively partaker and assistant of my brother William by contriving self-made instruments. . . . Often I would keep myself awake that I might listen to their animating remarks, for it made *me so happy to see them so happy*. But generally their conversation would branch out on philosophical subjects, when my brother William and my father often argued with such warmth that my mother's interference became necessary, when the names of Leibnitz, Newton, and Euler, sounded rather too loud for the repose of her little ones, who ought to be in school by seven in the morning. But it seems that on the brothers retiring to their own room, where they shared the same bed, my brother William had still a great deal to say; and frequently it happened that, when he stopped for an assent or reply, he found his hearer was gone to sleep; and I suppose it was not till then he bethought himself to do the same.
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> "The recollection of these happy scenes confirms me in the belief that, had my brother William not then been interrupted in his philosophical pursuits, we should have had much earlier proofs of his inventive genius. My father was a great admirer of astronomy, and had some knowledge of that science; for I remember his taking me into the street to make me acquainted with several of the most beautiful constellations, after we had been gazing at a comet which was then visible. And I well remember with what delight he used to assist my brother William in his various contrivances in the pursuit of his philosophical studies, among which was a neatly-turned four-inch globe, upon which the equator and the ecliptic were engraved by my brother."

But this little household was soon broken up, the regiment of Guards being ordered to England in 1755. The parting scenes are thus described:

> "In our room all was mute, but in hurried action; my dear father was thin and pale, and my brother William almost equally so, for he was of a delicate constitution, and growing fast. Of my brother Jacob, I only remember his starting difficulties at every thing that was done for him, as my father was busy to see that they were equipped with the necessaries for a march. The whole town was in motion, with drums beating to march; the troops hallooed and roared in the streets, the drums beat louder. Griesbach came to join my father and brothers, and in a moment they were all gone. My sister fled to her own

> room. Alexander," [her third brother] "went with many others to follow their relatives for some miles, to take a last look. I found myself now with my mother, alone in a room all in confusion, in one corner of which my little brother Dietrich lay in his cradle; my tears flowed, like my mother's, but neither of us could speak. I snatched a large handkerchief of my father's from a chair, and took a stool to place it at my mother's feet, on which I sat down, and put into her hands one corner of the handkerchief, reserving the opposite one for myself. This little action actually drew a momentary smile into her face."

They were gone a year, and of this period of separation she gives no recollections; but in her account of their welcome home we see how affectionate she was and how neglected she felt, and the kind treatment of her brother William could not fail to make a deep impression upon her susceptible nature:

> "My mother, being very busy in preparing dinner, had suffered me to go all alone to the parade to meet my father, but I could not find him anywhere, nor anybody whom I knew; so at last, when nearly frozen to death, I came home and found them all at table. My dear brother William threw down his knife and fork and ran to welcome, and crouched down to me, which made me forget all my grievances. The rest were so happy at seeing one another again that my absence had never been perceived."

In 1757 it became apparent that William had not the strength to stay in the Guards in war time, and his parents, with no small difficulty, sent him away to England.

When very young, Caroline went to the garrison school till three in the afternoon, and then to another school to be taught knitting. From the time she was six or seven years old, she says:

> "I was fully employed in providing my brothers with stockings, and remember that the first pair for Alexander touched the floor when I stood upright, finishing the front. Besides this my pen was frequently in requisition for writing, not only my mother's letters to my father, but many a poor soldier's wife in our neighborhood to her husband in camp."

From 1757 till 1760 there is another gap in the record, several pages having been torn from her manuscript belonging to this period. In 1760 her father came home for good, broken in health and worn out with hardships, and we are again furnished with some details of the family history. He devoted himself for the rest of his life to the musical education of his children, and gave lessons besides to the numerous pupils who sought his instruction. Next to her brother William, her father was the object of her dearest love. She was her mother's companion and, assistant, and, as the income was straitened, they together did all the housework. The mother was a diligent spinner, and kept the family well stocked with household linen. Her sister had not a patient temper, and was sometimes left, with her goods and chattels, to be taken care of by her mother. As to Jacob, who was often at home, and who developed into a dandy while in England, she speaks of him as follows:

> "When he came to dine with us it generally happened that before he departed his mother was as much out of humor with him as he was at the beef-steaks being hard, and because I did not know how to clean knives and forks with brick-dust." And again: "When he honored the humble table with his presence, poor I got many a whipping for being awkward at supplying the place of footman or waiter."

It is said that his love of luxury was shown in the specimens of English goods and English tailoring he brought back with him from England, while all that William brought back was a copy of Locke "On the Human Understanding," which took all his private means.

When her father came home to stay he helped her some, and yet, poor man, he did it under difficulties. The parents had never agreed upon the subject of her education. She says:

> "My father wished to give me something like a polished education, but my mother was particularly determined that it should be a rough but at the same time a useful one; and nothing further she thought was necessary but to send me two or three months to a seamstress to be taught to make household linen. Having added this accomplishment to my former ingenuities, I never afterward could find leisure for thinking of any thing but to contrive and make for the family, in all imaginable forms, whatever was wanting; and thus I learned to make bags and sword-knots long before I knew how to make caps and furbelows. . . . My mother would not consent to my being taught French, and my brother Dietrich was even denied a dancing-master, because she would not permit my learning along with him, though the entrance had been paid for us both; so all my father could do for me was to indulge me (and please himself) sometimes with a short lesson on the violin, when my mother was either in good-humor or out of the way. Though I have often felt myself exceedingly at a loss for the want of those few accomplishments of which I was thus, by an erroneous though well-meant opinion of my mother, deprived, I could not help thinking but that she had cause for wishing me not to know more than was necessary for being useful in the family; for it was her certain belief that my brother William would have returned to his country, and my eldest brother not have looked so high, if they had had a little less learning. . . . But sometimes I found it scarcely possible to get through with the work required, and felt very unhappy that no time at all was left for improving myself in music or fancy-work, in which I had an opportunity of receiving some instruction from an ingenious young woman whose parents lived in the same house with us. But the time wanted for spending a few hours together could only be obtained by our meeting at daybreak, because by the time of the family's rising, at seven, I was obliged to be at my daily business. Though I had neither time nor means for producing any thing immediately, either for show or use, I was content with keeping samples of all possible patterns in needlework, beads, bugles, horsehair, etc., for I could not help feeling troubled sometimes about my future destiny; yet I could not bear the idea of being turned into an abigail or housemaid, and thought that with the above and such like acquirements, and with a little notion of music, I might obtain a place as governess in some family where the want of a knowledge of French would be no objection."

As year by year passed by, William's attachment to England grew stronger. But the poor father, who was failing in strength, became more and more eager for his return, and on the 2d of April, 1764, to the great joy of the family, he made his appearance. The visit was brief, and gave no hope that he would settle in Hanover. In describing it, Caroline is spoken of as "the poor little unnoticed girl," and the event as standing in her memory "fraught with anguish too deep for words." She was disappointed in her hope of enjoying this visit of her brother, for it came at the time of her confirmation. She says:

> "With my constant attendance at church and school, besides the time I was employed in doing the drudgery of the scullery, it was but seldom I could make one of the group when the family were assembled together."

The Sunday fixed for his departure was the very day on which she was to receive her first communion:

> "The church was crowded and the door open. The Hamburger post-wagon passed at eleven, bearing away my dear brother, from whom I had been obliged to part at eight o'clock. It was within a dozen yards from the open door; the postilion giving a smettering blast on his horn. Its effect on my shattered nerves I will not attempt to describe, nor what I felt for days and weeks after. I wish it were possible to say what I wish to say, without feeling anew that feverish wretchedness which accompanied my walk in the afternoon with some of my school-companions, in my black-silk dress and bouquet of artificial flowers, the same which had served my sister on her bridal day. I could think of nothing but that on my return I should find nobody but my disconsolate father and mother, for Alexander's engagements allowed him to be with us only at certain hours, and Jacob was seldom at home except to dress and take his meals."

The last years of her father's life are thus described:

> "Changes of abode, not always for the better; anxieties, on account of Alexander's prospects, and Jacob's vagaries; disappointment at seeing his daughter grow up without the education he had hoped to give her—were the circumstances under which the worn-out sufferer struggled through the last three years of his life, copying music at every spare moment, assisting at a concert only a few weeks before his death, and giving lessons until he was obliged to keep wholly to his bed. He was released from his sufferings at the comparatively early age of sixty-one, on the 22d of March, 1767, leaving to his children little more than the heritage of his good example, unblemished character, and those musical talents which he had so carefully educated, and by which he probably hoped the more gifted of his sons would attain to eminence."

Caroline was now seventeen, with only the barest rudiments of education, and for the next two years the time passed uneventfully in household occupations; but at the age of twenty a new turn was suddenly given to her thoughts by the arrival of letters from William, proposing that she should join him at Bath, in England.

> "To make trial if by his instruction I might not become a useful singer for his winter concerts and oratorios, he advised my brother Jacob to give me some lessons by way of beginning; but that, if after a trial of two years we should not find it answer our expectation, he would bring me back again. This at first seemed agreeable to all parties, but, by the time I had set my heart upon it, Jacob began to turn the whole scheme into ridicule, and, of course, he never heard the sound of my voice except in speaking, and yet I was left in the harassing uncer

tainty whether I was to go or not. I resolved at last to prepare as far as lay in my power for both cases by taking every chance, when all were from home, to imitate, with a gag between my teeth, the solo part of concertos, *shake and all*, such as I had heard them play on the violin; and I thus gained a tolerable execution before I learned to sing. I next began to knit ruffles, etc. For my mother and Brother Dietrich, I knitted as many stockings as would last two years at least."

During all this time she was sorely troubled about her duty in the matter of leaving her mother, and she thus speaks of her feelings:

> "In this manner (making prospective clothes for them) I tried to still the compunction I felt at leaving relatives who, I feared, would lose some of their comforts by my desertion, and nothing but the belief of returning to them full of knowledge and accomplishments could have supported me in the parting moment. . . . My brother William, at last, quite unexpectedly arrived. . . . His stay at Hanover could at the utmost not be prolonged above a fortnight. . . . My mother had consented to my going with him, and the anguish at my leaving her was somewhat alleviated by my brother settling a small annuity on her, by which she would be enabled to keep an attendant to supply my place. . . . But I will not attempt to describe my feelings when the parting moment arrived and I left my dear mother and most dear Dietrich, on Sunday, August 16, 1772."

After a dismal journey of six days and nights, in an open post-wagon through Holland, and a stormy passage across the Channel, she arrived in England on the 26th, bareheaded, her bonnet having been blown into a canal from the post-wagon, and the first part of her "Recollections" ends with an account of her experiences in London at this time.

Before resuming Miss Herschel's diary it is needful to explain that, at the time she came to live with him, William Herschel was an eminent teacher of music at Bath, an organist with a choir under his management, a composer of anthems, chants, etc., and director of public concerts. But he followed music solely for the income it afforded; every leisure moment he could get by night or by day being devoted to the study of astronomy. He was known among his music-pupils as an astronomer, and some of them had lessons from him in this science as well as in music. He early applied his inventive talents to the improvement of telescopes. He began by getting from one of the shops a two-and-a-half-foot Gregorian telescope which served for viewing the heavens and for studying the construction of the instrument. Then he began to make instruments himself, which he went on improving and enlarging till at last the mirror for his great forty-foot telescope resulted. Such were the occupations of the brother whom Miss Herschel came to England to help. What she did and with what success is told in the following extracts from her "Recollections:"

> "On the afternoon of August 28, 1772, I arrived with my brother at his house at Bath, No. 7 New King Street. I knew no more English than the few words which I had on our journey learned to repeat like a parrot, and it may be easily supposed that it would require some time before I could feel comfortable among strangers. But, as the season for the arrival of visitors to the baths

does not begin till October, my brother had leisure to try my capacity for becoming a useful singer for his concerts and oratorios, and, being very well satisfied with my voice, I had two or three lessons every day, and the hours which were not spent at the harpsichord were employed in putting me in the way of managing the family. . . . On the second morning, on meeting my brother at breakfast, he began immediately to give me a lesson in English and arithmetic, and showed me the way of booking and keeping accounts of cash received and laid out. . . .

"My brother Alexander, who had been some time in England, boarded and lodged with his elder brother, and with myself occupied the attic. The first floor, which was furnished in the newest and most handsome style, my brother kept for himself. The front-room, containing the harpsichord, was always in order to receive his musical friends and scholars at little private concerts or rehearsals. . . . Sundays I received a sum for the weekly expenses, of which my housekeeping book (written in English) showed the amount laid out, and my purse the remaining cash. One of the principal things required was to market, and about six weeks after coming to England I was sent alone among fishwomen, butchers, basket-women, etc., and I brought home whatever in my fright I could pick up. . . . My brother Alexander used to watch me at a distance, unknown to me, till he saw me safe on my way home. I knew too little of English to derive any consolation from the society of those who were about me, so that, dinner-time excepted, I was entirely left to myself."

Of the progress of her musical education, we are told that she was much hindered by being continually called upon to assist in the manufacture of telescopes:

"It soon appeared that my brother was not contented with knowing what former observers had seen, for he began to contrive a telescope eighteen or twenty feet long, and I had to amuse myself with making the tube of pasteboard for the glasses, which were to arrive from London, for at that time no optician had settled at Bath. . . . My brother wrote to inquire the price of a reflecting mirror for, I believe, a five or six foot telescope. The answer was, there were none of so large a size, but a person offered to make one at a price much above what my brother thought proper to give. . . . About this time he bought of a Quaker at Bath, who had made attempts at polishing mirrors, all his rubbish of patterns, tools, hones, polishers, unfinished mirrors, etc., but all for small Gregorians, not above two or three inches in diameter.

"Nothing serious could be attempted, for want of time, till the beginning of June, when some of my brother's scholars were leaving Bath; and then, to my sorrow, I saw almost every room turned into a workshop. A cabinet-maker making a tube and stands of all descriptions in a handsomely-furnished drawing-room; Alexander putting up a huge turning-machine (which he had brought in the autumn from Bristol, where he used to spend the summer) in a bedroom, for turning patterns, grinding glasses, and turning eye-pieces, etc. At the same time music durst not lie entirely dormant during the summer, and my brother had frequent rehearsals at home, where Miss Farinelli, an Italian singer, was met by several of the principal performers he had engaged for the winter concerts. . . . He composed glees, catches, etc., for such voices as he could secure. As soon as I could pronounce English well enough I was obliged to attend the rehearsals, and on Sundays at morning and evening service.

"But every leisure moment was eagerly snatched at for resuming some work which was in progress, without taking time for changing dress, and many a lace ruffle[1] was torn or bespattered by molten pitch, etc., besides the danger to which he continually exposed himself by the uncommon precipitancy of all his actions, of which we had a sample one Saturday evening, when both brothers returned from a concert between eleven and twelve o'clock, my eldest brother pleasing himself all the way home with being at liberty to spend the next day (except a few hours' attendance at chapel) at the turning-bench; but, recollecting that the tools wanted sharpening, they ran with a lantern and tools to our landlord's grindstone, in a public yard, where they did not wish to be seen on a Sunday morning. But my brother William was soon brought back fainting by Alexander, with the loss of one of his finger-nails. . . .

"My time was much taken up with copying music and practising, besides attendance on my brother when polishing, since, by way of keeping him alive, I was constantly obliged to feed him by putting victuals in his mouth. This was once the case when, in order to finish a seven-foot mirror, he had not taken his hands off from it for sixteen hours together. Generally I was obliged to read to him, while he was at the turning-lathe or polishing mirrors, 'Don Quixote,' 'Arabian Nights Entertainment,' the novels of Sterne, Fielding, etc.; serving tea and supper without interrupting the work, and sometimes lending a hand. I became in time as useful a member of the workshop as a boy might be to his master in the first year of his apprenticeship. But, as I was to take a part the next year in the oratorios, I had for a twelvemonth two lessons per week from Miss Fleming, the celebrated dancing-mistress, to drill me for a gentle-woman (God knows how she succeeded!). So we lived on, without interruption."

On her first public appearance as the leading treble singer in the oratorios, her brother gave her ten guineas for her dress, and on the occasion the proprietor of the theatre pronounced her an ornament to the stage. If she had chosen to persevere, her biographer says her reputation as a singer would have been secure, but, like a woman, she thought more of securing her brother's success than her own. She steadily declined to sing in public unless he was conductor. Besides regular Sunday services, she sang in concerts and oratorios at Bath and Bristol, all the while carrying on her housekeeping with one servant. In this way for ten years at Bath she went on "singing when she was told to sing, copying when she was told to copy, lending a hand in the workshop," and sympathizing with all the intensity of her nature in the course of events, which ended by her brother becoming "the king's astronomer." She sang with him for the last time at Bath, on Whitsunday, 1782.

The following extract narrates the course of events that led to her becoming her brother's constant assistant in his astronomical work:

"My brother applied himself to perfect his mirrors, erecting in his garden a stand for his twenty-foot telescope. Many trials were necessary before the required motions for such an unwieldy machine could be contrived. Many attempts were made by way of experiment against a mirror, before an intended thirty-foot telescope could be completed, for which, between-whiles (not interrupting the observations with seven, ten, and twenty foot, and writing papers for both the Royal and Bath Philosophical Societies[1]), gauges, shapes, weights, etc., of the mirror were calculated and trials of the composition of the metal were made. In short, I saw nothing else and heard nothing else talked of but about these things when my brothers were together. Alexander was always very alert, assisting when any thing new was going forward, but he wanted perseverance, and never liked to confine himself at home for many hours together. And so it happened that my brother William was obliged to make trial of my abilities in copying for him catalogues, tables, etc., and sometimes whole papers which were lent him for perusal: I was thus kept employed when my brother was at the telescope at night. When I found that a hand was sometimes wanted, when any particular measures were to be made with the lamp, micrometer, etc., or a fire to be kept up, or a dish of coffee necessary during a long night's watching, I undertook with pleasure what others might have thought a hardship."

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[1] She means her brother's ruffles. In those days lace was worn by gentlemen, and she elsewhere speaks of knitting ruffles for her brother.

Although the sister's references to the labors and discoveries of her brother are full of interest, we have no space for them here. Suffice it that, after the discovery of "the Georgium Sidus in 1781, the name of William Herschel became famous, and he was soon released from the necessity of giving any of his time to music. He was sent for to come with his seven-foot telescope to the king, and the result was that he was chosen royal astronomer, at a salary of £200 a year." One or two extracts, from the letters written by William Herschel to his sister during this preliminary visit to London, will give some idea of the intimate relation she held in his life. He writes on May 25th:

" . . . . Yesterday I dined with Colonel Walsh, who inquired after you. There were present Mr. Aubert and Dr. Maskelyne. Dr. Maskelyne, in public, declared his obligation to me for having introduced to them the high powers, for Mr. Aubert has so much succeeded with them that he says he looks down upon 200, 300, or 400, with contempt, and immediately begins with 800. He has used 2,500 very completely, and seen my five double stars with them. All my papers are printing, with the postscript and all, and are allowed to be very valuable. You see, Lina, I tell you all these things. You know vanity is not my foible, therefore I need not fear your censure. Farewell.

"I am your affectionate brother, WILLIAM HERSCHEL."

And again, June 3d, he writes:

"DEAR LINA: I pass my time between Greenwich and London agreeably enough, but am rather at a loss for work that I like. Company is not always pleasing, and I would much rather be polishing a speculum. . . . I am introduced to the best company. To-morrow I dine at Lord Palmerston's, next day with Sir Joseph Banks, etc., etc. Among opticians and astronomers nothing now is talked of but *what they call* my great discoveries. Alas! this shows how far they are behind, when such trifles as I have seen and done are called *great*. Let me but get at it again! I will make such telescopes and see such things—that is, I will endeavor to do so."

The letter ends abruptly.

Such, in brief, was the intellectual and moral preparation of Miss Herschel for the life of an astronomer. An account of her experiences in this field will be given in our next number.

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[1] He was elected a Fellow of the Royal Society December 6, 1871.

CORRESPONDENCE.

LEX TALIONIS.

To the Editor of the Popular Science Monthly.

THE authors of "The Unseen Universe" tell us, as appears in a note in your January number, "It is probable that, before many years have passed, electricity will be called upon by an enlightened Legislature to produce absolutely indescribable torture, thrilling through every fibre of such miscreants"—in referring to "human brutes who vent their despicable passions in murderous assaults on women and children."

Evolution by reversion is not encouraging.

The refinement of scientific training, indicated by the above extract, is hardly in the direction of improving civilization.

It is suggested that the "human miscreants" are not the products of accident. May they not be examples of inherited disease, and therefore properly fit subjects for insane asylums, or other similar reformatories? How far may not society itself, in the locality of these human monsters, be responsible for their existence?

May we not hope that an "eye for an eye" is, in the order of healthy evolution, to disappear entirely from our penal correctives, including that relic of barbarism, capital punishment, even now rapidly disappearing from our statute-books, and in most States inflicted only for one grade of crime?

What is the object of all rational punishment? Certainly not vengeance—not vindictiveness.

Is it not, rather—1. Restitution to society or to individuals, so far as possible, for loss or injury caused by criminals? 2. Protection of society from repetition of criminal acts? and, 3. Reformation of the culprit?

If the gallows, and "absolutely indescribable torture, thrilling through every fibre," provided by *enlightened* Legislatures, are the only infallible remedies, then, indeed, is our vaunted civilization a sad failure.

Let us *revert* to scientific inquisition at once, and have a commission of *savants* in this Centennial year of grace, to resurrect the beauties of Torquemada. Why not?

B.

RICHMOND, INDIANA, *January* 10, 1876.

EDITOR'S TABLE.

MARTINEAU'S REPLY TO TYNDALL.

ONE of the great characteristic elements of scientific knowledge is that it is progressive, and the nature of that progress is to arrive gradually at the establishment of truth. Science having fixed upon its methods—methods that have been vindicated in its history—goes on with the exploration of phenomena in all fields, by beginning with imperfect evidence and gradually working out its investigations to the completeness of proof and the firm establishment of facts and principles. This being so, it follows that those who lead in science, who are active in its preliminary work, are naturally the most obnoxious to all those classes who rest contented with the existing state of opinion and are the conservators of traditional belief. It has always been so. In every phase and stage of advancing science, it is those that push on with the pioneer work, who begin to question opinions long rooted, trusting to the wholesomeness of inquiry, and the validity of long-tested scientific procedure, that encounter denunciation as disturbers of the world's intellectual peace. It was those who initiated investigation in astronomy, geology, physiology, and the various branches of natural phenomena; and it is those who are now pushing scientific methods of thought into fields where they have hitherto been unrecognized, that are most obnoxious to criticism as meddlers, disturbers, and destructives. The world at length accepts the work, and when it is accomplished will even applaud those who began it; but it as yet by no means recognizes the necessity of sharper questioning, of exploration in new fields, of a more inexorable scrutiny of old opinions, or the necessity of accepting the initial work of pioneer thinkers as legitimate and indispensable.

And so it is that intrepid scientists like Prof. Tyndall, who push on the front and give battle right and left, must take the consequences, as their predecessors have done in the past. The President of the British Association took a step forward at Belfast, and has been in hot water ever since. He assumed the broad, advanced ground that the exploration of the universe, so far as it is accessible to human faculties, belongs to science; and that every system, doctrine, or belief, that has hitherto been put forth regarding the nature, origin, or government of the universe which lays claim to the character of knowledge, must submit its pretensions to be passed upon by the tribunal of science. Science having given to man the universe as we know it, has established its claim to be intrusted with the whole field of intellectual exploration into its methods and laws. It was undoubtedly a bold step for President Tyndall to take, but it was inevitable by the logic of the history of thought. That the batteries should have been opened upon him all around was quite natural, and is but the repetition upon a somewhat larger scale of what has been going on in a smaller way ever since the scientific study of Nature began.

One of the controversies which grew out of the position taken by Tyndall, before the British Association, was with Dr. James Martineau, who is carrying it on vigorously and expansively. He first attacked the Belfast Address in a discourse entitled "Religion as affected by Modern Materialism," delivered to the theological college of which he is principal. To this Prof. Tyndall replied in a new preface to the "Fragments of Science," which appeared in the MONTHLY of last December. Dr. Martineau now rejoins in the February *Contemporary*, in an elaborate article, with more to come. We should be glad to print his paper if it were within limits practicable for the MONTHLY. But twenty-three pages, with the expectation of as many more, would consume more space than we can spare, and it is of less importance that we should issue it, as Mr. Putnam, Dr. Martineau's American publisher, will shortly furnish it to interested readers.

We may, however, briefly take note of Dr. Martineau's general position. He assumes that mischiefs arise, to both science and theology, from confusing their boundaries, and these he attempts to define. He seems to regard them as coördinate departments of investigation, and "that, in their dealings with phenomena, science investigates the 'How,' and theology the 'Whence.'" But on this view theology becomes obviously but one division of science, and is swallowed up by it. In investigating the "how" of things we are simply inquiring into one phase of their order, and in investigating their "whence" we are but inquiring into another phase of the same order. Moreover, we are finding that the investigation of the "how" involves the investigation of the "whence;" so that both procedures are directed to the solution of a common problem. Where are the defining boundaries when one thing is lost in another?

The more common theological position takes the "whence" out of the field of scientific inquiry by relegating it to the supernatural, and assuming it to be settled by an infallible preternatural inspiration, which is above the sphere of science that deals only with the natural. Orthodoxy plants itself upon the divine, infallible record, which by its nature and source is claimed to be above the reach of science. But Dr. Martineau is heterodox and cannot take this ground. His position is, that the Bible is sacred, but not infallible—sacred like the sacred books of other religions. He says: "I am asked how, after giving up the Old Testament cosmogony, I can any longer speak of 'sacred books,' without informing my readers where to find them . . . . Can a literature, then, have nothing sacred unless it be infallible? Has the religion of the present no roots in the soil of the past, so that nothing is gained for our spiritual culture by exploring its history and reproducing its poetry, and ascending to the tributary waters of its life? The real modern discovery, far from saying there is no sacred literature, because none oracular, assures us that there are several; and, notwithstanding a deepened, because purified attachment to our own 'origenes' in the Jewish and Christian Scriptures, persuades us to look with an open reverence into all writings that have embodied and sustained the greater pieties of the world."

By this position the absorption of theology into science is complete. For if Christianity has no other or different claims for the validity of what it offers than half a dozen other religions have—and impliedly a hundred other religions—what remains but to accept the phenomena of religions as a part of the phenomena of Nature open to scientific exploration? And, if thrown upon Nature, we encounter unity and evolution, and must study the genesis of religious beliefs, the development of superstitions, and the derivation of theological systems, as we study the unfolding of life, or the origin and progress of human institutions. The underlying principle of evolution is continuity, the lowest being connected with the highest by unbroken lines of unity and causation. But though committed, as we think, to this view by the position he has taken, Dr. Martineau affirms a break in the upward movement, so abrupt and total that science cannot cross it. He says, "Nature, in respect of its higher affections, compassion, self-forgetfulness, moral obligation, is constructed in harmony with a world divinely ruled," and this is the sphere of intuition and theology where science does not belong. But does the divine rule necessarily rule out science? and are not intuitions in this higher realm as open to be inquired of scientifically as instincts in the lowest sphere? The writer's declarations that it is the office of theology to explore the "whence" of things, and that it pertains to the "upper zone" of human nature, do not quite clear up the confusion of its boundary relations to science.

Dr. Martineau labors to point out, in his present essay, the difficulties that the "materialist" must encounter in explaining things by the atomic hypothesis; and in his next article he promises to show the deficiencies of the dynamic hypothesis for the same purpose. It is unnecessary to say that, as a writer, Dr. Martineau is an accomplished master of rhetorical effect.

A LIBEL UPON THE INDIANS.

It is an interesting question how the different races of mankind rank as liars. Is the capacity to falsify a constant quantity in all the varieties of men, or does it vary like other qualities; and, if variable, is it subject to development, and how do the various tribes of men stand upon the scale?

A United States Senator has given us his decisive *dictum* upon the subject, and there ought to be wisdom in a senatorial *dictum*. Mr. Windom, of Minnesota, is reported as recently saying in the Federal Senate that "the Indians are the greatest liars and vagabonds upon the face of the earth." With their rank as vagabonds we have no immediate concern, but in regard to their grade as liars we think the Senator is in error; he is over-modest; the "greatness" which he so freely accords to the savages, in this respect, belongs preeminently to his own race. The rivalries of falsehood between races, like other rivalries, must depend upon capacity, culture, and opportunity; and, in any competition for honors in deception, the Yankee has proved from the beginning to be much "smarter" than the Indian. Our Senator, indeed, if the reports can be trusted (and they are white, not Indian reports), might be taken as a living and conclusive illustration of the superiority of the superior race in perpetrating falsehood on an imposing scale. He is said to have advocated a breach of the treaty by which the "Black Hills" are reserved to the Sioux, so as to let in all the white adventurers that choose to go there; that is, to break the faith and pledge of the Government, and turn the whole nation into liars by virtue of our representative system. This brings out the exalted advantages in the practice of falsification possessed by the dominant race over the uncultivated savages. We can perpetrate deceit by official machinery. Even in the smallest way, in the hand-to-hand competition of a huckstering trade, the Yankee may be trusted anywhere to circumvent, that is, to outlie the Indian. But when we consider the case in its broader aspects, where the two sorts of people work freely in their separate social spheres, the Indians are not to be named as competitors of the whites in the art of mendacity. Granting the disposition, they lack the resources and capacity. Mentally, they are children, with but little knowledge, scanty ideas upon a few subjects, and limited intellectual operations. They lack the scope, the cultivation, the facilities for exercise in deceit which are possessed by the civilized race. Without books, newspapers, advertisements, highly-organized party politics, diplomacy, lawsuits, complex business rivalries, sectarian strifes, big enterprises, and fashionable society, what can they do in the way of duplicity, fraud, imposition, misrepresentation, artifice, cheating, forgery, perjury, and the thousand forms, and grades, and variations of lying, in which the dominant race is so proficient? The civilized man multiplies his capacity of falsehood through division of labor. He not only lies with his tongue, but with his hands, manipulating falsehood into his manufactures. He lies by machinery, and swindles by steam. By the printing-press he scatters deceptions like snow-flakes over the continent. Your civilizee lies with enterprise, through an army of agents by post and by telegraph. What can the "poor Indian," with his "untutored mind," do in comparison with this? There was more lying in the management of the Northern Pacific Railroad than ten tribes of Indians could perpetrate in a generation. There is more lying in one presidential campaign than all the North American tribes could perpetrate in a century. The Indians are no more "the greatest liars on the face of the earth" than they are the greatest lawyers, politicians, editors, merchants, and manufacturers, on the face of the earth. Fraud, falsification, dissimulation, insincerity, trickery, overreaching, and the innumerable grades and shades of humbug, are vices of the civilized man, and he must accept this with all his other forms of greatness. The Indian has undoubtedly a rudimental capacity for lying, which gets somewhat developed along the borders, by his intercourse with the whites, but he cannot aspire to the unenviable eminence which Senator Windom ascribes to him.

HOW SCIENTIFIC EDUCATION IS EVADED.

Of the two great phases of educational reform, the improvement of its quality, and the increase of its quantity, in our judgment, as we have frequently said, the former is much the most important. We have abundant evidence on all sides as to how easy it is to extend education, or that which passes under its name. And the evidence is equally abundant and clear of the great difficulties of improving the quality of that which is established under the name of education. And the more it is extended and organized, and officialized, the more formidable are the obstacles to any change of method that shall make it increasingly rational. A fresh illustration of the tenacity of traditional ideas, and the ingenuity with which reforms of great and conceded importance are evaded and turned to naught, was lately furnished by Sir John Lubbock in pointing out the tactics of the leading English universities by which the study of science and the modern languages is escaped. To show how the subject stands as a matter of *reason* he first called attention to the views put forth by the several English commissions appointed to inquire into the management of the higher institutions. The commission of 1861, which took up the great public schools, reported that more time should be devoted to the study of modern languages, while, as regards science, that it was practically excluded from the education of the higher classes in England. "Education," they say, "is, in this respect, narrower than it was three centuries ago, while Science has prodigiously extended her empire, has explored immense tracts, divided them into provinces, introduced into them order and method, and made them accessible to all. This exclusion is, in our view, a plain defect, and a great practical evil. It narrows unduly and injuriously the mental training of the young, and the knowledge, interests, and pursuits, of men in maturer life. Of the large number of men who have little aptitude or taste for literature, there are many who have an aptitude for science, especially for science which deals, not with abstractions, but with external and sensible objects; how many such there are can never be known, as long as the only education given at schools is purely literary, but that such cases are not rare or exceptional can hardly be doubted by any one who has observed either boys or men."

In 1868 another commission was appointed to examine the management of the English endowed schools. In their report they say: "We think it established that the study of natural science develops, better than any other studies, the observing faculties, disciplines the intellect by teaching induction as well as deduction; supplies a useful balance to the studies of language and mathematics, and provides much instruction of great value for the occupations of after-life."

Finally, a third commission was appointed, under the presidency of the Duke of Devonshire, to inquire into the state of scientific instruction in Great Britain, and they report that "though some progress has no doubt been achieved, and though there are some exceptional cases of great improvement, still no adequate effort has been made to supply the deficiency of scientific instruction pointed out by the commissioners of 1861 and 1864. We are compelled, therefore, to record our opinion that the present state of scientific instruction in our schools is extremely unsatisfactory."

These are well-matured views put forth with the weight of a large number of the most eminent names in England. The claims of scientific men for time to be devoted to scientific studies have been moderate. Assuming the number of study-hours in a week to be thirty-eight, Dr. Hooker, Prof. Huxley, and Dr. Carpenter, ask only for six hours to be devoted to science, while Prof. Tyndall demands only eight. The recent commission has shown by a large number of returns from the endowed schools that, when science is studied at all, not more than two hours a week are given to it, while in a large number it is entirely ignored. Out of one hundred and twenty of the larger endowed schools, in more than half no science whatever is taught, and out of the whole number only thirteen attach any weight at all to scientific subjects in the examinations.

It is by the skillful working of these "examinations" that the adherents of the older studies resist the educational progress of science. The Universities of Oxford and Cambridge, backed by the immense authority of these great institutions, have recently appointed a joint board to undertake the examinations of schools. The studies are distributed in four groups: 1. The languages; 2. Mathematics; 3. Scripture knowledge, history, etc.; 4. The sciences. But the certificates are awarded under such conditions that the modern languages and the sciences are virtually suppressed. As Sir John Lubbock says, "the result will be to discourage the teaching of French and German," while "the nominal introduction of science is under the circumstances little more than a hollow mockery;" the effect being that "boys may obtain university certificates while they know nothing of history, nothing of geography, nothing of any modern language, or of any branch of science."

VIVISECTION VINDICATED.

There was a loud and passionate outcry a year ago in England, which had its echoes in this country, about the fiendishness of physiologists in their experiments upon living animals. They were represented as devoid of all humanity, indurated and indifferent to suffering, and as delighting to torture poor dumb creatures for mere amusement or class-room show, and on the most frivolous pretexts of helping on the progress of science. There was a great deal of screaming about it, and Hutton, of the London *Spectator*, led the crusade, demanding governmental interference to restrain the brutalities of the scientists and protect the helpless victims of their barbarity. And so, as is wont with the English, a commission was appointed to inquire into the matter, and Hutton was among the commissioners. It was a sensible body, and raked together every thing that claimed to be evidence upon the subject. Of course, the stories of horrors which got such wide credence, turned out to be absurd exaggerations. Brought to book, the secretary of the "Royal Society for the Prevention of Cruelty to Animals" acknowledged that he did not know a single instance of wanton cruelty. The case of the agitators broke down signally, and after the most patient examination of the whole subject the commissioners declare that "a general sentiment of humanity on this subject appears to pervade all classes in this country." They point out how much science is indebted, and how much the world owes, to experiments upon living animals, and they recognize that in the further progress of medical science this means of knowledge cannot be avoided. The commission, in fact, accepts the position taken by the physiologists themselves at the British Association in 1871, and demands only "the reasonable superintendence of constituted authority." The legislation asked for will not in any way alter the existing facilities for research or impede its progress, while it will calm needless apprehension, and put an end to the odious misrepresentations which have recently been rife upon the subject. Perhaps the friends of the lower animals, who have been so ardent in attacking and denouncing men of science, will now turn their attention to the butchers, the hunters, and the fashionable people who torture their horses in the broad day in the open streets, and at all hours, in the sight of everybody, by the use of bearing-reins and gag-bits.

LITERARY NOTICES.

Descriptive Sociology. By Herbert Spencer. Numbers Three and Four. Folio. Price, $4.00 per No. D. Appleton & Co.

To those who care only for politics on account of its gossip, personalities, and passing excitements, or who study it merely as an art for the attainment of their own selfish ends, these works need not be commended; but those who are interested in working out the principles of a science that underlies all politics will be glad to learn that the "Descriptive Sociology" of Herbert Spencer is making fair progress, the fourth number being now published. This work is not at all known even by the most intelligent portion of the American people. They talk much about society, speculating upon its origin, declaiming against its evils, and proposing endless nostrums for its relief and regeneration, but give no attention to the most serious, thorough, and successful effort yet made to elucidate the natural laws of social phenomena. If the value and importance of Spencer's "Descriptive Sociology" were at all understood, it would be found in every public library, in many private ones, and in all higher educational institutions. It is nothing less than a series of representations, almost pictorial in their clearness, of the constitution of human societies, of all forms, types, and grades, the world over. It gives the whole range of social facts that characterize each community in such an ingenious scheme of representation that they can be compared with extreme facility, and their elements considered either separately or as existing together; and either as advancing by themselves, or as moving on connectedly and under mutual influence. The industrial, economic, domestic, civil, military, æsthetic, moral, religious, and intellectual condition of each community, is given in a systematic way, which brings out the relations of these social factors; and the whole is carefully authenticated by copious and classified extracts from the best authorities by which the social facts in the several cases have been described. Without critical examination no one can form an idea of the enormous labor that has been expended upon these works, nor of their value to the students of social affairs. Nothing worthy the name of social science, that is, embracing wide inductions and comprehensive principles, can ever come from the examination of one example or form of society only; and, in the wide sweep of his inquiries, Mr. Spencer is the first to have given to the problem of social philosophy its full breadth of scientific basis.

In the first number of this general work Mr. Spencer gave us the social history of England. In the second number he gathered up and organized what is known of the social life of the extinct or decayed American civilizations. Number Three, now before us, is devoted to the lowest types of the social state—the Negritto races and the Malayo-Polynesian races. This was compiled and abstracted by Prof. David Duncan, a collaborator with Mr. Spencer in the execution of his enterprise. It represents the social life of the Fuegians, Andamans, Veddahs, Australians, Tasmanians, New Caledonians, New Guinea people, Fijians, Sandwich-Islanders, Tahitians, Tongans, Samoans, New-Zealanders, Dyaks, Javans, Sumatrans, and Malagasy. The environments, inorganic, organic, and sociological of these communities, and the physical, emotional, and intellectual characters of each people are given, and whatever is known or accessible regarding their social habits, peculiarities, and modes of life.

Number Four, which is just published, also elaborated by Prof. Duncan, is devoted to the African races. He delineates the social aspects of the Bushmen, the Hottentots, the Damaras, the Bechuanas, the Caffirs, the East Africans, the Congo people, the Coast Negroes, the Inland Negroes, the Dahomans, the Ashantis, the Fulahs, and the Abyssinians.

We cannot republish these works in the Monthly, although in the number for April, 1874, we gave a sample of the tables that are used, and which necessitated the large folio form of publication. But those who will take the pains to consult and compare these works now issued will quickly see that we are entering upon a new stage of social ideas and knowledge. "The proper study of mankind is man," but it is far from being the same study in different ages.

A TEXT-BOOK OF HUMAN PHYSIOLOGY. Designed for the Use of Practitioners and Students of Medicine. By AUSTIN FLINT, Jr., M. D. Illustrated by Three Lithographic Plates and 313 Woodcuts. Pp. 978. Price, $6. D. Appleton & Co.

THIS work is an abridgment or condensation of Dr. Flint's large treatise upon physiology, in five volumes. The bibliographical and historical features of the larger work are mostly omitted, and various subjects, which are there much elaborated, are more concisely presented in the single volume. The more extensive treatise will retain its place for purposes of reference, as giving a full account of the literature of physiology, and a systematic representation of its facts and principles. Out of this Dr. Flint has educed a complete working manual, which brings the treatment of the subject within convenient limits for students, while it is much more complete as a representation of the present state of the science than any other book we know upon this topic. A marked feature of the work is its illustrations, which are large and especially fine. Many of them are new, and all are executed in the best style of the engraver's art. The book is beautifully printed and is most attractive in appearance; it may be commended to all who desire a comprehensive and trustworthy work up to the latest date, by authority, on the interesting and important subject of physiology.

ANIMAL PARASITES AND MESSMATES. By J. P VAN BENEDEN, Professor at the University of Louvain. With 83 Illustrations. Pp. 274. Price, $1.50. D. Appleton & Co. No. XIX. of the "International Scientific Series."

WE give in the body of the MONTHLY a sample of the curious and interesting information on the economy of animal life to which this book is devoted. It opens a new chapter of strange things in the field of life, to the common reader, and will be perused with avidity by all lovers of natural history. The names of most of the little creatures described will be found somewhat new to general readers; but the lively, familiar, and graphic style of the writer will go far to compensate for this drawback, as he is not without a very decided sense of the comical and humorous side of his remarkable subject. The author is an eminent authority in zoölogy, and the work is largely the result of his own observations and studies. It is one of the most original monographs in the series to which it was contributed.

LIFE HISTORIES OF ANIMALS, INCLUDING MAN: OR, OUTLINES OF COMPARATIVE EMBRYOLOGY. By Dr. A. S. PACKARD, Jr. New York: Henry Holt & Co., 1876. Pp. 243. Figures 268.

SINCE the translation of Siebold's "Comparative Anatomy of the Invertebrata," by Dr. Burnett, accompanied by the valuable investigations of the translator, and the publication of "Mind in Nature," by Prof. H. James Clarke, there has been no general work published in this country equaling in importance the one before us. Indeed, we cannot now recall any work which covers the same ground; and as an evidence of its value it may be stated that the English magazines of science have repeatedly made liberal quotations from some of the chapters, as they originally appeared in the *American Naturalist.*

Dr. Packard has not only brought together and richly illustrated a *résumé* of the labors of the leading embryologists of Europe—Kowelevsky, Schultze, Schneider, Metschnikoff, Salensky, Cienkowski, and others equally distinguished—and also the work of American naturalists, too, but has contributed much original matter from his own published works on insects and crustacea. The various classes are conveniently but not too rigidly grouped in a natural sequence, commencing with the *Monera,* and ending with *Man.*

It is refreshing to get hold of a general work which is strictly in accordance with the latest interpretations of science, and it must remain for many years the one standard work on the subject.

The author, as is the case with ninety-nine hundredths of the leading investigators, is an evolutionist, and indeed it would be difficult to conceive a work of this nature presented in any other light, unless it were given as a bare descriptive catalogue of details.

With each group (considered as a special study) are given a brief sketch of the structure and habits of some of its leading forms, their affinities, embryology, and a very useful table of the literature of the subject. A list of the authors referred to indicates clearly how few Americans have contributed to a knowledge of the subject.

The advanced character of the work is seen in the adoption of Haeckel's terms for different conditions of the embryo, such as the *morula stage*, *planula stage*, *gastrula stage*, etc. The ascidian stage is also recognized in the development of Vertebrata. *Amphioxus* is considered separately from the fishes, the *Brachiopoda* are placed among the worms. Altogether it forms one of the most valuable works of science yet published in this country, and it is safe to say that no working naturalist can do without it.

As a second edition of the work must soon be demanded, we trust it may be accompanied by a table of contents.

Abstract of Results of a Study of the Genera Geomys and Thomomys, with Addenda on the Osteology of Geomyidæ. By Dr. Elliot Coues. Washington: Government Printing-Office, 1875. Pp. 74.

This is a reprint from Major J. W. Powell's report of his explorations of the Colorado River, giving a full scientific account of the little animals known on the Western prairies as Pocket *Gophers*. Regarding the two genera *Geomys* and *Thomomys* as constituting a perfectly natural group of the grade of a family, *Geomyidæ*, the author describes them as "among the heaviest for their inches of any animals in this country, of squat, bunchy shape, with short, thick limbs, a short tail, very small or rudimentary ears, small eyes, no appreciable neck, and thick, blunt head; and they are as completely subterranean as the mole itself. They are rarely or momentarily seen above the ground; they excavate endless galleries in the earth in their search for food, frequently coming to the surface to throw out the earth in heaps, but plugging up these orifices as soon as they have served their purpose."

Geomys contains five (some authors say seven) well-defined species; *Thomomys* but a single species, including three recognizable races, out of which, by the process of species-mongering so common with earlier naturalists, a dozen separate species were made. While in *Geomys* the links have disappeared and the species are well-pronounced, in *Thomomys* the separation is incomplete, and the connecting forms still visible. "The genus appears to be working into a number of species, but the process is still far from completion." Adopting modern philosophical views, the author's tendency is to reduce the number of species, seeing only races or varieties where others claim to have found well-defined species. The several species constituting the family are separately described. The cranial and dental characters of the group are afterward treated, and the work closes with a further description, communicated by Prof. G. Brown Goode, of *Geomys tuza*, a form confined to Florida, Alabama, and Georgia, and there known as Salamanders.

Prof. Coues has the rare faculty of making even technical descriptions interesting, and for this reason the work commends itself to the attention of other than scientific readers.

Practical Hints on the Selection and Use of the Microscope. By John Phin. New York: The Industrial Publication Co., 1875. Pp. 131. Price, 75 cts.

In the preface to this little book the author tells us that it is intended for beginners in the use of the microscope, a purpose that appears to have been kept well in mind in the subsequent pages, as the explanations are clear, the directions explicit and suitably detailed; and nothing has been attempted that lies beyond the understanding of any intelligent girl or boy of fifteen. After pointing out the numerous applications of the instrument, that are every day extending, the simple and compound microscope, and the essential parts of each, are described. The various forms in use are next enumerated, with brief descriptions of the most noted; and then follow practical directions for the selection of a microscope, and the requisite accessory apparatus. Illumination, the manipulation and care of the instrument, and the collection and mounting of objects, take up the remainder of the book. The student is referred to the larger works of Carpenter and others for a knowledge of the principles involved in the construction of the microscope, and of the course of procedure in the several departments of study to which it is applied.

FOUR THOUSAND MILES OF AFRICAN TRAVEL. By ALVAN S. SOUTHWORTH, Secretary of the American Geographical Society. With Maps and Illustrations. Baker, Pratt & Co., New York. Price, $3.50.

THE volume of Mr. Southworth is an interesting contribution to our knowledge of one of the most important regions of Central Africa. It is the well-told account of a journey made by the author as traveling correspondent of the *New York Herald* for the purpose of exploring the countries of the Upper Nile—their aspects, resources, and populations.

The journey commenced at Cairo on the 27th of December, 1871. "At noon on the 6th of February," says the traveler, "our Soudan *dahabeah* was parting the dark, rippling waters of the Blue Nile from the muddy flow of its sister confluent, the White Nile, and by one o'clock the solitary minaret of Khartoum was seen above the palms and acacias!" This city contains 40,000 inhabitants, is the capital of the Soudan, and is the finest provincial city of Central Africa.

The chapters in which the author gives an account of his trip up the White Nile through the heart of the Soudan are full of interest. The country is described as wonderfully fertile. With its present wretched cultivation it is more productive than the well-tilled fields of Italy. It abounds in cattle and camels, as well as wild animals. Under the present government the progress toward civilization has been immense. Within fifteen years we are informed, 30,000,000 people have been brought in some degree within the circle of semi-civilization. But only incipient steps are taken. The slave-trade and all the depressing influences of savagism still bear upon the people. It is believed that no country in the world is better adapted to the raising of cotton than the Soudan.

The author turned back from his travels at Arbah Island, 300 miles southward from Khartoum, and nearly 2,000 miles from the Mediterranean.

The volume is enlivened by vivid descriptions of natural scenery and phenomena. On the Nubian Desert the mirage sometimes breaks the dreary view. "On the 17th of January we were seemingly encompassed by this imponderable mirror. In the glowing heat the bed of the desert would seem to rise in rippling waves, and a line of rocks, at 200 yards distance, kept common time and looked like a regiment of men marching off the field in line of battle." The simooms, sand-storms, and sand-spouts, as well as the gorgeous tropical scenery, are vividly described. The horrors of the slave-trade, and the means by which this and other barbarisms may be overcome, are prudently and judiciously treated. Dr. Southworth has done excellent service in publishing this volume.

THE AMERICAN JOURNAL OF MICROSCOPY AND POPULAR SCIENCE. Issued by the Handicraft Publication Company, 37 Park Row, New York. Subscription price, 50 cents a year

THIS is a twelve-page monthly devoted mainly to the interests of microscopy. Its purpose, as expressed in the prospectus, is to diffuse a knowledge of the best methods of using the microscope, of valuable improvements in the instrument, and its accessories; of new methods of microscopical investigation, and of the most recent results of microscopical research. Besides general articles, of which the number before us offers a pleasant variety, some of them illustrated, there is a "Young Folks' Column," "Our Work-Table," "Book-Table," "Notes and Queries," etc.

REPORT OF THE MICHIGAN BOARD OF HEALTH, 1874. Lansing: W. S. George & Co. Pp. 254.

AMONG the subjects treated in this report are the entailments of alcohol, draining for health, poisonous paper, relation of schools to health, resuscitation of the drowned, cerebro-spinal meningitis, meteorology of Central Michigan. Of the eight special reports, five were drawn up by Prof. R. C. Kedzie, M. D., whose labors are well known to all who take an interest in sanitary science.

A GUIDE TO THE MICROSCOPICAL EXAMINATION OF DRINKING-WATER. By J. D. MACDONALD, M. D., F. R. S. Pp. 113. With twenty-four Lithographic Plates. Price, $3. Philadelphia: Lindsay & Blakiston. 1875.

THIS volume is an important contribution to our knowledge of the extent and nature of the impurities found in drinking-water, and the most ready means of detecting and classifying them. In clearness of method and statement, and style of its illustrations, the work is admirable. The author does not attempt to link particular forms of impurity with specific sanitary effects, but says further observation may show their deep sanitary significance.

No one now hesitates to condemn a water containing bacteria and fungi, or swarming with the lower forms of life.

The means by which sediments and floating impurities in water may be best obtained and studied is pointed out in a brief introduction.

Section 1 treats of the mineral matters found in drinking-water; section 2 gives an account of the dead and decaying, section 3 of the living forms found in water.

The twenty-four plates comprise over four hundred figures; frequently, however, the same object is presented under different forms. The volume is an excellent handbook, and will greatly facilitate the study of the important subject of which it treats.

EXPLORATION OF THE COLORADO RIVER OF THE WEST AND ITS TRIBUTARIES IN 1869, 1870, 1871, AND 1872. Washington: Government Printing-Office. Pp. 291.

THIS is the first installment of Major J. W. Powell's exploration and survey of the Colorado River region. The book consists of three parts, in the first of which we have a journal of the exploration of the cañons of the Colorado in the year 1869; in the second, an account of the physical features of the valley of the Colorado; and in the third, three chapters on the zoölogy of the region explored. The two chapters of the second part were published in the MONTHLY last summer, Major Powell kindly permitting us to copy from advanced sheets, and supplying us with the woodcuts. The present volume is an exceptionally interesting and instructive description of the strange and picturesque country explored.

THE CHOLERA EPIDEMIC OF 1873 IN THE UNITED STATES. Pp. 1025. Washington: Government Printing-Office.

CONTAINS reports made to the Treasury Department by Dr. Woodworth, superintendent surgeon of the Marine Hospital Service, and to the War Department by Dr. J. K. Barnes, Surgeon-General U. S. Army. Dr. Woodworth's report is brief, and traces the history of the introduction of cholera through the agency of the mercantile marine. The War Department report is divided into three parts, the first being written by Dr. Ely McClellan, U. S. Army. This gives a history of the epidemic of 1873 in the United States. The second part, by Drs. J. C. Peters and Ely McClellan, is devoted to the history of the travels of Asiatic cholera. In the third part is given the bibliography of cholera by Dr. J. S. Billings, U. S. Army.

NOTES ON CERTAIN EXPLOSIVE AGENTS. By WALTER N. HILL, S. B. Boston: John Allyn, 1875. Pp. 71.

THIS pamphlet contains a large amount of practical information about several of the more important explosives now in common use, such as nitro-glycerine and its various preparations, gun-cotton, and the picrates and fulminates. Their chemical composition, mode of preparation, manner of firing, and the reactions which occur during explosion, are clearly set forth, and tables are also given exhibiting their relative explosive power.

THE TAXIDERMIST'S MANUAL: OR, THE ART OF COLLECTING, PREPARING, AND PRESERVING OBJECTS OF NATURAL HISTORY. By THOMAS BROWN, F. L. S. New York: G. P. Putnam's Sons. Pp. 150. Price, $1.25.

THIS is a practical guide to the art of taxidermy, giving detailed directions for all the operations required in the preparation and mounting of natural history specimens. It contains several plates and a full index.

SOUL PROBLEMS, WITH OTHER PAPERS. By JOSEPH E. PECK. New York: Charles P. Somerby. Pp. 63. Price, 70 cents.

THE problems considered in this essay are the materiality or immateriality of the mind, and future personality. The other papers are on "The Theological Amendment," and "The State Personality Idea."

STARTLING FACTS IN MODERN SPIRITUALISM. By N. B. WOLFE, M. D. Chicago: Religio-Philosophical Publishing House. Pp. 571.

DR. WOLFE tells us that he has been for twenty-five years an observer of modern spiritualism. Had he not published this book, the world might never have known the extent of his gullibility. He has only himself to blame.

CONTRIBUTIONS FROM THE LABORATORY OF THE STATE UNIVERSITY. By P. SCHWEITZER, Ph. D. Jefferson City, Mo.: Regan & Carter. 1875. Pp. 38.

Two papers by Prof. Schweitzer, printed from the Catalogue of the University, comprise this pamphlet. One is upon the "True Composition of Coal," and the other on the "Water-Supply of Columbia, Boone County," with analyses. Both papers are of value, giving in detail the results of faithful and well-directed laboratory work.

VIEWS AND INTERVIEWS ON JOURNALISM. Edited by CHARLES F. WINGATE. New York: F. B. Patterson. Pp. 372.

MR. WINGATE allows some of the prominent newspaper editors of the United States to express their opinions on journalism, its limits, its tendencies, its perils, its prospects. In some instances the editors are catechised in an interview, in others their views are ascertained by reference to the journals they edit.

THE LOWER FORMS OF LIFE FOUND WITHIN THE ORAL CAVITY. By C. N. PEIRCE, D. D. S. Pp. 23. Lancaster, Pa.: *Pennsylvania Journal of Dental Science.*

THE forms of life here spoken of are six in number, five of them being vegetal growths, and the sixth an animal organism, a genus of infusorium. They are all microscopic organisms.

THE PROSPECTOR'S MANUAL. By W. J. SCHOFIELD. Boston: W. J. Schofield & Co. Pp. 96. Price, 50 cents.

INTENDED as a guide to the discovery of quartz and placer indications of gold and silver mines. The book further gives descriptions of metalliferous rocks of various kinds in the New England States and the neighboring provinces of Canada.

JOURNAL OF THE AMERICAN ELECTRICAL SOCIETY. Vol. I., No. 1. Chicago: Lakeside Publishing Co. Pp. 98.

THE American Electrical Society, whose official organ this *Journal* is, has for its object the interchange of knowledge and the professional improvement of its members, the advancement of electrical and telegraphic science, and the establishment of a central point of reference. The articles which appear in the *Journal* consist chiefly of papers read at the meetings of the society, but papers from other sources on telegraphic and electrical subjects are also given. In the present number, the first article, which is well illustrated, is by Mr. Elisha Gray, on "The Transmission of Musical Tones telegraphically." There is also an illustrated article on "Quadruplex Telegraphy." Among the selected articles we may name one on Edison's "New Force," by Dr. Beard, and a sketch of Sir Charles Wheatstone. The Publishing Committee, in a note prefixed to the present number, state that a second number may be issued in three or four months. Price, $1.50 per number.

GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA (1874). By N. H. WINCHELL. Pp. 36. St. Paul *Pioneer Press* print.

IN this, his third annual report, the State geologist of Minnesota gives the results of his researches on the geology of the two counties of Freeborn and Mower. In the former county there is an abundance of peat, most of the marshes being peat-bearing. This peat is of the best quality, and is gradually coming into use for fuel. Geological maps of the two counties accompany the report.

BULLETIN OF THE UNITED STATES NATIONAL MUSEUM. By J. H. KIDDER, M.D. Washington: Government Printing-Office. Pp. 51.

THE present number of the "Bulletin" is devoted to a description of the ornithological specimens brought from Kerguelen Island by the Transit-of-Venus Expedition of 1874–'75. The number of species described is twenty-one, belonging to six families — *Procellaridæ*, *Spheniscidæ*, *Laridæ*, *Phalacrocoracidæ*, *Anatidæ*, and *Chionididæ*.

Bulletin of the Buffalo Society of Natural Sciences. 1875. Buffalo, N. Y.: The Courier Company, Printers. Pp. 120.

This issue is No. 4 of Vol. II., and comprises nine articles, with an index to the volume. The articles are No. 16 to No. 24 of the series, eight of which are upon subjects of entomology, and all of value to specialists in that science.

No. 18 is a check-list of the North American sphinxes by Aug. R. Grote, and No. 20 is a valuable paper by Dr. Scudder, being a synonymic list of the butterflies of North America north of Mexico.

Article No. 22, by M. C. Cooke, M. A., of London, is a synopsis of the discomycetous fungi of the United States, in which very full credit is given to American mycologists for assistance rendered.

Necessity of a Mechanical Laboratory. By Prof. R. H. Thurston. Pp. 10.

Prof. Thurston here defines what a mechanical laboratory ought to be, its province and its methods. Such a laboratory the trustees of the Stevens Institute of Technology, he informs us, have consented to establish. Such bodies as the Railway Master-Mechanics' Association, the Society of Civil Engineers, and the Iron and Steel Association, have pledged themselves to give aid and advice in promoting the enterprise.

Some Account of Zapus Hudsonius and Lagopus Leucurus. By Dr. E. Coues. Washington: Government Printing-Office. Pp. 14.

Zapus is the name given by Dr. Coues to a genus which includes only one species, the "long-legged mouse of Hudson's Bay." This animal, usually referred to the *Muridæ*, differs from the Muridæ, says Dr. Coues, to a degree warranting the recognition of a family *Zapodidæ.* With respect to *Lagopus leucurus* (the white-tailed ptarmigan), Dr. Coues remarks upon its breeding-habits, its nest, and its eggs.

The Mammoth Cave of Kentucky. By W. S. Forwood, M. D. Philadelphia: Lippincott. Pp. 241.

This is an excellent account of the great Kentucky Cave. It is not only a trustworthy guide for the visitor, but something far better than an ordinary guide-book—an historical and descriptive account of the Mammoth Cave, giving explanations of the causes concerned in its formation, its chemistry, geology, etc., together with full scientific details of the eyeless fishes. The volume has twelve lithographic illustrations, also an original map.

Geological Notes. By Prof. William B. Rogers. Pp. 13.

The two papers contained in this pamphlet are reprinted from the "Proceedings of the Boston Society of Natural History." The first of the papers treats of the Newport conglomerate, and the second of the gravel and cobble-stone deposits of Virginia and the Middle States.

Weights, Measures, and Money, of All Nations. By F. W. Clarke, S. B. Pp. 117. New York: D. Appleton & Co. Price, $1.50.

This is a very useful little volume, enabling the reader to reduce to United States standards the money, measures, and weights of every commercial nation in the world. The work is divided into two parts, in the first of which we have a classification according to countries, arranged alphabetically, and, in the second, a set of tables, giving the value of each unit both in English and in metric standards.

PUBLICATIONS RECEIVED.

Washington Astronomical and Meteorological Observations (1873). Washington: Government Printing-Office. Pp. 429.

Reconnoissance of Northwestern Wyoming. By W. A. Jones, U. S. A. Washington: Government Printing-Office. Pp. 332.

Algebraical Equations. By J. Macnie, A. M. Pp. 194. New York: A. S. Barnes & Co. Price, $2.50.

History of the United States. By J. A. Doyle. Pp. 404. New York: Holt & Co. Price, $1.40.

Beliefs of the Unbelievers. By O. B. Frothingham. New York: Putnams. Price, $1.

French Political Leaders. By E. King. Pp. 326. *Same publishers.* Price, $1.50.

Filth-Diseases. By J. Simon, M. D. Pp. 96. Boston: James Campbell. Price, $1.

Percy Bysshe Shelley as a Philosopher and Reformer. By C. Sotheran. Pp. 51. New York: Somerby. Price, $1.25.

Algebra for Beginners. By J. Loudon, M. A. Pp. 158. Toronto: Copp, Clark & Co.

Report on the Public Schools of Columbus, Ohio. Pp. 428. Columbus: S. A. Glenn.

The Textile Colorist (Monthly). For sale in New York by Wiley & Son. Price, $1 per number.

Report of New York City Superintendent of Schools (1875). Pp. 77. New York: Cushing & Bardua print.

Report on the Harvard Museum of Comparative Zoölogy (1875). Pp. 58. Boston: Wright & Potter print.

Message of Governor Tilden (January, 1876).

Chemical Analyses of Fertilizers. Published by the Georgia Commissioner of Agriculture. Pp. 44.

The Bible and Science. By J. Weiss. Pp. 22. Boston: Cochrane & Sampson print.

Sheep-Husbandry in Georgia. Pp. 24. Atlanta: Harrison & Co. print.

Sympathy of Religions. By T. W. Higginson. Pp. 38. Boston: Free Religious Association. Price, 10 cents.

The Financial Problem. By Hon. E. Ward. Pp. 18. Washington *Congressional Record* print.

Charities of New York (1876). Pp. 69. New York: Putnams.

Sketch of the Life of J. A. Lapham. By S. S. Sherman. Pp. 80. Milwaukee: *News* Co. print.

Man's True Relation to Nature. By T. P. Wilson, M. D. Pp. 26. Cleveland, Ohio: L. H. White.

Sanitary Condition of Towns. Pp. 32 (Legislative Document). Albany: Weed, Parsons & Co. print.

Elements of Life-Insurance. Pp. 32. Boston: Wright & Potter print.

Variation in Strength of a Muscle. Pp 6. *Also*, New Form of Lantern Galvanometer. Pp. 3. By F. E. Nipher. Reprint from *American Journal of Science.*

Specimens of Milk from Vicinity of Boston. By S. P. Sharples, S. B. Pp. 7.

Valedictory Address to the Medico-Legal Society of New York. By C. Bell. Pp. 22.

Meteorology and Health. By W. Blasius. Pp. 5.

MISCELLANY.

Trichinous Pork.—*Trichina spiralis* was first discovered by Owen, in 1835, in human muscular tissue. Some twenty years later the parasite, as seen by Owen, namely, as a minute worm coiled up within a cyst, was found by Herbst to be the larva of a thread-like worm. The latter passes its life in the intestinal canal, the former inhabits the muscular tissue. When the flesh of animals infested by the larvæ is taken into the stomach, the immature trichinæ quickly multiply, and in the course of a few days millions of the encysted larvæ may be found in the muscles. As has been shrewdly conjectured, it is not improbable that the prohibition of pork as food, a prohibition enforced not only among the Jews, but among various races inhabiting widely-separate regions of the earth, had its origin in an observation of injurious consequences attending the use of swine's flesh. Dr. Sutton's "Report on Trichinosis," noticed in our January number, is worthy of the attention, not only of medical men, but of the public. We give herewith the result of his observations on the cases of the disease which came under his notice, and of his examination of hundreds of specimens of pork:

1. He found that all the cases which came under his observation were produced by eating uncooked or imperfectly-cooked pork. 2. He reiterates the uniform teaching of medical observers that the vitality of the trichinæ can be destroyed only by thorough cooking of the meat, and that the eating of merely smoked or dried pork is dangerous. 3. From microscopic examinations of pork killed in Southeastern Indi

ana, he found from three to sixteen per cent. of the hogs affected with trichinæ, the number of hogs diseased varying greatly in different localities. 4. That ninety per cent. of the disease produced by trichinous pork appears as gastero-enteritis, diarrhœa, or dysentery, ten per cent. only representing the cases of trichinosis proper.

Penetrating Power of Different Colored Lights.—An experiment was lately made at Trieste, to determine how far lights of different colors penetrate darkness. Half a dozen lanterns with carefully-selected glass, and all furnished with oil and wicks of the same quality, were lighted on the beach, and then observations were made by a party in a boat. At the distance of half a league, the dark-blue lantern was invisible, and the deep-blue one nearly so; hence it appears that blue lights are not adapted for use in lighthouses, or as signals. Of all the colors the green was visible for the longest distance, with the exception of the red, which ranked next to the white in power of penetration. The conclusion is, that only the green and the red are suitable for signals; and the green light the Trieste observers only recommend for use in conjunction with white and red lights, inasmuch as, when viewed from a short distance, an isolated green light begins to look like a white one.

Curious Freak of the Curly-Willow.—The following curious facts are communicated by Dr. S. Lockwood to the *Botanical Bulletin:* "We have two pendent willows, known as *Salix Babylonica* (more correctly *S. pendula*, Mœnch.), the weeping-willow, and *Salix crispa*, the curly-willow. On the grounds of Hon. E. W. Scudder, Trenton, New Jersey, is a fine specimen of each, the two having a clear distance of twenty-five feet between their nearest branches. The topmost branch of the curly-willow, on the side of the tree next the weeper, is about ten feet long, and six feet thick, and is densely covered with leaves. The curious fact is, that while the rest of this entire tree has the perfect habit of *S. crispa*, this large branch has the perfect habit of *S. Babylonica*. The long pendent branchlets, and every leaf, are in all respects those of the weeping-willow. This is true not only of the form and habit of the leaves, but with positive exactness also of the color. The true *crispa* leaves are a very dark and shiny green above, and almost a chalky white underneath. The pseudo-*Babylonica* leaves are a pale yellowish-green above, and still paler, perhaps pea-green, on their under sides. I compared them carefully with the leaves of the neighboring *Babylonica*, and, excepting perhaps that the leaves of the freak were a little the smaller, a fact of no significance, there was no difference whatever. Looking at this great branch, the spectator comes to regard it as a natural graft. This is an utter mistake. It is purely an outcropping of heredity, and is thus an interesting evidence of the identity of species in the curly and the weeping willow. Supposing *S. Babylonica* to be the ancestor, we have here the long-dormant inherited force asserting itself, and proclaiming the ancient and wellnigh lost parentage of *S. crispa*. It is observable, too, that the foliage of the branch, thus representing the true weeper, is much more dense than that on the rest of the tree representing the curly-willow. This is the fact respecting these trees everywhere. The curly-willow has this to its disadvantage, its paucity of foliage, so that, in pointing back to its ancestry, it declares the leaf-wealth of the ancient line. As the tree is a very old one, it is significant that this declaration of heredity should appear so late in life."

A Wise Public Benefactor.—In 1868 Sir Joseph Whitworth presented to the British nation an annuity of £3,000 per year, which was vested in the Department of Science and Art, for the purpose of founding scholarships to promote the instruction of young men in the theory and practice of mechanics and the cognate sciences. He has now made over to the public his large landed estates for similar purposes, reserving to himself a life interest. The Department of Science and Art is to hold the estates, subject to the control of Parliament. In commenting upon this munificent action of Sir Joseph Whitworth, the London *Times* commends his wisdom in trusting Parliament to adapt his endowment to the varying circumstances of successive times. "We have had," says the *Times*, "abundant instances of late years of the manner in which what the Lord-Chancellor describes as a 'perpetual trust' has hampered, instead of fostering, the development of the future. It is not merely that so much money has been wasted, but obsolete rules and exploded systems have been a lasting obstacle to the growth of thought and to the intelligent adaptation of new generations to new necessities. The law of mortmain has not been sufficient to avert this danger, and great institutions like our universities and public schools have from time to time come to a dead-lock. Being established with no other dominant object in view than that of perpetuating the systems of the past, a troublesome outcry has always been raised when it has become necessary to adapt them to the present."

Diffusion of Cholera.—Pettenkofer's theory of the spread of cholera—namely, that it depends on geological and hydrological conditions—receives confirmation from the researches of Dr. Decaisne, one of the foremost hygienists of France. In a communication to the Académie des Sciences, Dr. Decaisne calls attention to the fact that the cities of Lyons and Versailles have always been in a great measure proof against this disease, though the country round about has again and again been ravaged by it. Paris, on the contrary, has often suffered severely from cholera. In 1832 Lyons entirely escaped the visitation of the epidemic, which ravaged all the rest of the country. Again, in 1835, Lyons was not attacked by the cholera in its advance up the Rhone. In 1849 it made its appearance in one of the barracks, and a few cases occurred in the neighborhood; but three weeks later it had disappeared. In the autumn of 1853 the cholera prevailed in the department of Drôme; there was an outbreak at Lyons, the number of cases being 400, with 196 deaths. In 1865 there were only a few sporadic cases.

According to Pettenkofer's theory, the immunity of Lyons is explained partly by the constitution of the soil, but this explanation applies only to those quarters of the town which overlie the granite rock, either directly, or with a bed of clay interposed. All those portions of the city which rest on the alluvium owe their immunity to peculiar conditions of the underground water. The two instances mentioned above of outbreaks of the cholera in Lyons coincide with periods of exceptional drought, when organic matter, which is usually submerged, underwent decomposition by the action of the air. But those portions of the city which owe their salubrity to the physical constitution of the soil have always enjoyed immunity. As for the city of Versailles, the conditions there are analogous to those found at Lyons. But Paris rests on Eocene Tertiary formations which are permeable and dry—conditions which are favorable to the dissemination of cholera.

Coal-Deposits in New York State.—In a recent popular lecture on the subject of coal, given under the auspices of the Buffalo Society of Natural Sciences, Prof. A. R. Grote speaks as follows of the prospects of finding coal within the limits of the State of New York: "Though coal exists in small quantities in the earth below the carboniferous formation, it will not pay to mine it. The Marcellus shale, for instance, is so charged with bitumen that it can be burnt. A great deal of money has been wasted in this State in searching for coal in formations where it could not be found. More money, a thousand times over, has been frittered away than would pay for a new scientific survey of the State, which is so much needed. Instead of consulting scientific men, geologists, people have dug vainly, and wasted time, labor, and money. Within the borders of our State we have no carboniferous formations, except a bare outcropping, in the southwestern part, of conglomerate belonging to the series. No coal exists in this State in any quantity."

Observations on the Migrations of Birds.—With a view to ascertain the conditions governing the migrations of birds and certain other periodical phenomena, the natural-history editor of *Forest and Stream* invites the attention of observers throughout the country to the subject, and suggests that each one keep a record of his observations. The points to be specially observed are the following: 1. Whether each species of birds is resident throughout the year, is a summer or winter visitant, or only passes over a locality in spring or fall. 2. With reference to each species in a given locality, whether it is "abundant," "somewhat common," or "rare." 3. What species breed, and whether more than once in a season. 4. Dates of arrival, greatest abundance, nest-building, laying eggs, hatching of young, and beginning of departure of each species, and when it is last seen in the fall. 5. What effects, if any, upon the relative abundance of particular birds, in retarding their arrival or hastening their departure, sudden changes of the weather, storms, and late and early seasons appear to have. 6. Similar notes upon the appearance and movements of the quadrupeds, reptiles, and fishes of the region, and upon the time of flowering of trees and plants. 7. Other occurrences considered noteworthy. It is desirable that records of this kind should be kept. As the writer in *Forest and Stream* observes, it is through such observations as these, continued year after year, that the natural history of England has become so well known, and so many persons there have become interested in it. We may add that children might easily be induced to take an interest in this kind of natural-history observations, and so by degrees acquire the faculty of accurately noting what is going on around them.

Arctic Research.—A commission of thirteen eminent naturalists, appointed by the German Government to discuss the question of Arctic discovery, have made a report, in which they adopt the advice of Lieutenant Payer, of the Austrian Expedition. They do not object to Arctic research, but dissuade from voyages of discovery; they believe that the advantages to be derived from the former can be secured by a safer and surer method. They recommend the establishment of permanent stations in those Arctic regions which can be safely approached and abandoned at any time. As a beginning, they recommend several stations to be formed on the eastern shore of Greenland, the western shore of Spitzbergen, and Jan Mayen Island. Houses should be built, furnished with every regard to the inclemency of the climate. In each house the commission would have stationed a detachment of scholars, sailors, and other enterprising men, to remain for a term of years, a ship being sent out for their relief from time to time.

The men at these stations could do good work for meteorology, by observing the periodic recurrence of Arctic phenomena, as well as any deviation from the ordinary rule, and would thus be enabled to discover the reasons for the alternation of storm and calm at the equator. The connection between terrestrial magnetism and atmospheric electricity, cable-currents, and the aurora borealis, can only be investigated in such high latitudes; while the laws of terrestrial magnetism itself will never be thoroughly appreciated unless the variations of magnetism in the far north are studied. Then as to astronomy, the theory of refraction, the atmospheric lines of the spectrum, and the relation between comets and shooting-stars, to be better known, require continued observation near the pole. Geodesy, too, by measurement of degrees and observation of the pendulum, will arrive at more definite conclusions respecting the form of the globe.

Geography, independently of the topographical details to be ascertained on the spot, will derive the most valuable geognostic information from further systematic study. Geology, paleontology, mineralogy, botany, and zoölogy, may expect to make great strides from persistent exploration of the northern and southern poles, while physiology and biology will be enormously advanced by the discovery of the conditions of life in those cold regions. There was a time when man in Central Europe led the life to which Lapps and Eskimos are condemned nowadays. To become familiar with the manners and customs, the religion and morals, the physical and psychical peculiarities of Arctic races, is to dive into the distant past, and may probably explain much that is still unintelligible in our primeval history.

Force and Work.—Work without implies work within. No exercise of force can be made except by the generation and use of force of which no part enters into the external result. The use of muscles involves use of nerves. The external force, if exerted by a muscle, is only part of that which it produces. Now, the proportion between these two in their several degrees is a subject of great practical importance, and some interesting facts have recently been published by Helmholtz. From these it is clear that the greater the external force exerted the greater is the proportion of the needful internal force—that is, great exertion is more wasteful than moderate exertion. Then force has to be evolved in proportion to the external work done, and therefore the greater is the wear and tear of the animal machine. The same increased proportion of non-productive work is seen when the external energy is below a moderate amount. It is found, for instance, that in walking, a speed of three miles an hour gives the most economical use of the forces. No doubt in these facts we have an index to much of the ill effects of the present high-pressure rate of work and life. The waste of force is out of proportion to the work done. More is effected in a given time, but the body feels it more, and its working period is proportionately shorter. These facts cannot be too often repeated or too constantly remembered by those who have the regulation of labor.—*Lancet.*

Contributions to Meteorology.—The *American Journal of Science*, for January, contains the fourth paper by Prof. Loomis, giving results of recent researches in the science of meteorology, founded on data derived chiefly from the weather-maps of the United States Signal Service.

In a former article attention was called to the fact that low temperatures at the surface of the earth are produced by descent of *cold air from the upper regions of the atmosphere.* It was shown that, in areas of high barometer, the movement of the air is outward from the centre, instead of inward, as in case of low barometer or storm. This implies a supply from downward motion.

The current notion, that extreme cold is brought by wind from colder areas, is met by the fact that, at Yakootsk, in Siberia, which is about the coldest place in the Northern Hemisphere, the temperature is lowest when the air is quite still, and equally when the wind is from north, south, east, or west. These results are obtained from four years' observations at that place, and are similar to those obtained at New Haven, except as to direction of wind. It would be difficult to explain where the extreme cold of Yakootsk came from, except from the upper atmosphere, seeing that it is colder than the country round about.

A diurnal variation in the progress of storms was noticed by Prof. Loomis in a former paper. This fact suggested to him the further one that there is a diurnal inequality in the rainfall. This is now shown by observations made at Philadelphia, not by the Signal Service maps, which do not record hourly observations. It appears that the maximum rainfall occurs at about six o'clock in the afternoon; and the minimum at three o'clock in the morning.

By observations which cover a period of ten years, made at Prague, in Bohemia, it appears that the greatest rainfull during the day occurs in the afternoon, the maximum being from three until six o'clock.

The tracks of storms in America and Europe, already noticed by Prof. Loomis, are further considered in this paper. He determined the precise latitude at which the storm-centres cross certain lines of longitude, and in this way establishes a line which is the track of the storm-centre; a similar method was applied to storms in Europe. It appears that the average track is not regular, but varies. In an article published in July, 1874, it was stated that the average direction of the storms of the United States was, for the year, 8° north of east, and that is correct as a general statement. Connected with the present article is a chart, by which it is seen that the average track of American storm-centres is over Chicago and Detroit, and is deflected to the south coast of Newfoundland. From this point it seems to be continuous over the ocean, being deflected northward near the Irish coast, passes over Dublin, and thence across Denmark. These results, however, are obtained from the Paris maps, and the continuity of the line may, in some measure, depend on the extent of the field of observations by which it was determined.

The number of storms traced across the Atlantic Ocean is not large; they undergo changes on the ocean, and frequently are merged in other storms.

The velocity with which storms advance is further considered in this paper. It was previously stated that the rate might vary from a stationary condition for many hours, or several days, to the extreme velocity of 1,200 miles in a day, or even 57.5 miles an hour.

By an examination of European maps it appears that storms over Europe travel at an average rate of 26.7 miles per hour, and it was found from examination of American maps that they move at about the same rate in this country. But over the Atlantic Ocean the movement is only 19.6 miles, showing that the velocity is less over the ocean than over the land.

This proves that the progress of a storm is not merely a drifting of the atmosphere; for, observes the professor, it seems probable that the average progress of the atmosphere in an easterly direction is as rapid over the Atlantic Ocean as it is over North America.

How Rats and Mice use their Tails.—To test the correctness of the popular belief that rats and mice use their tails for feeding purposes, when the food to be eaten is contained in vessels too narrow to admit the entire body of the animal, a writer in *Nature* made the following experiments: Into a couple of preserve-bottles with narrow necks he put as much semi-liquid fruit-jelly as filled them within three inches of the top. The bottles were then covered with bladder, and set in a place frequented by rats. Next morning the covering of each bottle had a small hole gnawed in it, and the level of the jelly was lowered to an extent about equal to the length of a rat's tail if inserted in the hole. The next experiment was still more decisive. The bottles were refilled to the extent of half an inch above the level left by the rats, a disk of moist paper laid upon the surface, and the bottles covered as before. The bottles were now laid aside in a place unfrequented by rats, until a good crop of mould had grown upon one of the moistened disks of paper. This bottle was then transferred to the place infested by the rats. Next morning the bladder had again been eaten through at one edge, and upon the mould were numerous and distinct tracings of the rats' tails, evidently caused by the animals sweeping their tails about in the endeavor to find a hole in the paper.

Experiments in Beet-Culture.—In the course of their experiments on beet-culture, Dehérain and Fremy planted some beets in absolutely sterile soils, to which were added from time to time such substances as were thought to be essential for the development of the plant. It was found that the beets continued in the rudimentary state when they received in such soils only distilled water; they increased slightly in weight when common water took the place of distilled; their development was greater still when the water contained soluble phosphates, or salts of potash; but yet the roots never attained the weight of 100 grammes. When for these mineral substances were substituted ammoniacal salts or nitrates, the yield was much better. Normal beets, however, cannot be grown unless to these nitrogenous fertilizers are added phosphates and potash salts. It is worthy of note that, when the beet finds in the soil nitrogen, phosphorus, potash, and lime, it develops as well as in a soil containing humus. To establish this point Messrs. Dehérain and Fremy compared the produce of two such soils, and found that the beets grown in sterile soil were heavier than those grown in rich soil.

On examining the beets grown in plots in the experimental garden of the museum, the authors found them to be very poor in sugar, though the soil was very rich. From this it follows that deficiency of sugar in the beet is not due to exhaustion of the soil. In seeking the true cause, it occurred to Messrs. Dehérain and Fremy to ascertain how much nitrogen the beets contained, and found it to be very large. Hence it appeared that a soil rich in nitrogeneous matters is unfavorable to the production of sugar. This conclusion was confirmed by sundry analyses of beets grown at the museum, at the school of Grignon, and in the departments of Aisne, Nord, and Eure. All the results positively confirm the observations made by the authors, and their conclusion is that, if beets are now less rich in sugar than formerly in those departments which have long produced them, that fact is not owing to the exhaustion of the soil and its deprivation of principles necessary for the development of the beet; on the contrary, the reason of the phenomenon is, that the soil is too rich in nitrogenous matters, in consequence of the liberal use of manures.

Balloons and Carrier-Pigeons.—It is related by a writer in the London *Quarterly Review* for July, that when Pilâtre de Rozier had descended safely to the earth, after making the first aërial voyage ever undertaken by man, Benjamin Franklin, who at the time (November 21, 1783) was in Paris, on being asked his opinion of the brothers Montgolfier's invention, replied, "A child has just been born." But hitherto its growth has been extremely slow. Nevertheless, the history of aërial navigation is full of interest, and it is well told by the writer in the *Quarterly*. Some of the early objections against ballooning were singular enough. Thus, it was urged that female honor and virtue would be in continual peril, if access could be had by balloons at all hours to the windows of houses! Politicians objected that, if the path of air were to be made free, all limits of property and frontiers of nations would be destroyed. As a matter of course, aërial navigation was denounced as "impious." And, when the brave Pilâtre des Rozier's balloon took fire in the air over the city of Boulogne, and he lost his life, many a one recognized herein the "hand of Providence," just as the peasant-girl, who saw a deal chair fall "from heaven," at once decided that it was a part of the household furniture of the angels. In point of fact, Gay-Lussac, who happened at the time to be overhead, had thrown the chair out of his car, to lighten his aërostat.

During the siege of Paris by the Germans, a balloon post was established in the city. At first there appeared to be innumerable obstacles in the way of this enterprise, the chief one being the difficulty of obtaining a sufficient number of aëronauts. In this strait, the aid of seafaring men resident in the city was invoked, as their training had made them familiar with operations and dangers akin to those of ballooning. From September to January, sixty-four balloons were sent off, and of these fifty-seven fulfilled their mission. The number of letters thus dispatched was 3,000,000. The writer in the *Quarterly Review* mentions one incident connected with these balloon voyages which seems hardly credible: On one occasion, the crew of a balloon found themselves over the sea, out of sight of land. Seeing vessels they made signals for help, but were not answered, *and one vessel fired on them.* The men afterward descended to the earth in Norway.

To carry dispatches and letters *into* Paris, carrier-pigeons were employed. The dispatches, public and private, were first printed on pages of folio size, 16 of which were placed side by side, forming a large sheet about 54 inches long by 32 wide. This was reduced by photography to $\frac{1}{800}$ of its original area, the impression being taken on a small pellicle of collodion, two inches long and 1¼ wide, and weighing about ¾ of a grain; each contained about 2,000 words, or 32,000 words in all, equal to about 58 pages of this magazine. Every pigeon carried twenty of these leaves, which were carefully rolled up and put in a quill. At the Government office in Paris, the quill was cut open, and the collodion leaves carefully extracted. They were then magnified by an optical apparatus, copied, and sent to their destination.

Mental Overwork.—One of the great evils of modern life, in the estimation of many eminent physicians, is mental overwork. It is asserted that affections of the heart are now more numerous than ever before, that asylums for the insane are being overcrowded, and that nervous disorders of every kind are on the increase. What are the signs which indicate impairment by overwork? This question is thus answered in the *Sanitary Record*: "Overwork," says the *Record*, "exists when the sense of energy once possessed is distinctly impaired; when it is found an effort to get through what was once a cheerful task; when what was once found comparatively easy is beginning to be felt a trial; and above all when errors or omissions, the direct outcomes of a flagging and wearied brain, commence to manifest themselves. To spur on an exhausted brain, and by application and longer hours of toil to compel the overtaxed nervous system to complete its round of duty, is one of the most disastrous and erroneous measures that can be adopted. Whenever work, itself unaltered, looks larger than of yore, and is felt to be more trying, then the system is commencing to feel the effects of overwork, which, however, may actually have existed for some time unnoticed. This is especially true of the monotonous labor which is undergone by the clerks and subordinate officials of our commercial houses; if they are free from the anxieties which affect the principals, they are the more subject to the wearing action of monotonous labor. The institution of bank holidays is a step in the right direction, and ere long the absolute necessity for a more decided increase in the number of national holidays will be palpable enough. What man can safely do is not to be measured by his desires, but by his powers; and we are all rapidly becoming convinced that incessant toil is not only undesirable, but that it is uneconomical. The one day's rest in seven is not now sufficient for our needs."

French Public Libraries.—In a statistical work, comparing France with other European countries, the following interesting notes on public libraries occur: Paris has six great libraries, the property of the state, and open to the public, viz.: Bibliothèque Nationale (900,000 volumes), Bibliothèque Mazarine, Bibliothèque de l'Arsenal, Bibliothèque Sainte-Geneviève, Bibliothèque de la Sorbonne. Outside of Paris France has 338 libraries which twenty years ago contained 3,689,000 printed volumes. Forty-one of these libraries are open in the evening. Great Britain has (in its public libraries) 1,771,493 volumes, or six volumes per 100 of the population; Italy 11.7 volumes per 100. In France there are 4,389,000 volumes, or 11.7 per 100 persons; in Austria 2,488,000 volumes, or 6.9 per 100; Prussia 2,040,450, or 11 per 100; Russia 852,000, or 1.3 per 100; Belgium 509,100, or 10.4 per 100. Since 1865 school libraries have been founded nearly throughout all France. We have already in the MONTHLY given the statistics of these school libraries, but we copy the figures again from the work to which we are indebted for the foregoing statistics. In 1865 there were 4,833 of these school libraries in France, containing 180,854 volumes; in 1866, 7,789 libraries, 258,724 volumes; 1867, 11,417 libraries, 721,853 volumes; 1868, 12,395 libraries, 988,728 volumes; 1869, 14,395 libraries, 1,239,165 volumes; 1870–'71, 13,638 libraries, 1,158,742 volumes.

Appearances attending the Passage of a Meteor.—In stating the results of his observations on the passage of a meteorite seen at Louisville, December 12, 1872, Prof. J. Lawrence Smith says that it first appeared as a large red light in the zenith, which seemed to stand motionless for several seconds, evidently because it was then descending in a line with the eye of the observer. Then starting off with an uncertain, faltering motion, it moved slowly toward the horizon, gradually fading from a lurid red to a dark purplish hue, and leaving a dense stream of blue smoke behind, which remained for several minutes. "These clouds," continues Prof. Smith, "are not unfrequently connected with the passage of these bodies through our atmosphere, and are usually more striking in the daytime, or, as in this instance, just after sunset, when the sun was well situated to light up the cloud and exhibit it to the observer who could no longer see the sun. What are these clouds? Are they composed of impalpable matter abraded from the surface of these bodies in their passage, or are they true vapor-clouds? From a close study of observations in connection with several well-known falls of meteorites, I am more inclined to adopt the former view; but there is reason for believing that the violent disturbance of a portion of the atmosphere (much of it, in the rapid passage of the body, undergoing great condensation), added to an undoubted electric disturbance of the atmosphere, would tend to the deposition of moisture, upon the atmosphere being gradually restored to its former equilibrium."

Insect-killing Plants.—During a botanical tour in Atlantic County, New Jersey, Mr. Meehan, of Philadelphia, found growing, near Hammonton, a great number of plants representing three species of *Drosera*, namely, *D. filiformis*, *D. longifolia*, and *D. rotundifolia*. All of these species had insects attached to them, but many of the plants had none. The remains of the insects which have been caught seem to continue attached to the plant for a long time, and thus the observer at once perceives which plant has had the benefit of animal food. No difference in health or vigor could be detected between those which had had insects and those which had not. This, however, does not by any means decide the question whether the plants do or do not digest the insects. As Mr. Meehan remarks, the case of these plants is comparable to that of vegetarians and flesh-eaters among mankind; it is a question which class is the healthier. A plant, he said, might feed on insects, and yet be no healthier than those which lived as other plants did. But the author does not see how this faculty of catching and digesting insects could be developed by natural selection. "It is believed," said he, "that the power to catch insects is a developed one—a power not possessed by their predecessors—and developed according to the law of natural selection. Unless insect-catching can be shown to be an especial advantage, there is nothing to select." Among the many *Droseras* observed by Mr. Meehan on this occasion, only one presented the phenomenon of the leaf bending over on itself, and so enfolding the prey.

The Soda-Lakes of Wyoming.—An account of the soda-lakes of Wyoming Territory is given in the report of Mr. Pontez, geologist of the Union Pacific Railroad. He describes two such lakes, the larger one covering about 200 acres. The average depth of water in this lake is three feet, and its specific gravity 1.097. The soda is nearly all carbonate. The second lake is situated near the first, and covers about 3½ acres. During the greater part of the year it is a concrete mass of carbonate-of-soda crystals. Mr. Pontez excavated to the depth of six feet without reaching the bottom of the deposit, which is constantly increasing from the influx from the larger lake. These lakes are situated about 65 miles from Rawlins Station, on the Union Pacific Railroad. The quality of the carbonate is declared to be fully equal to the imported article. Estimating the quantity by the specific gravity of the water, its depth and area, the large lake would yield on evaporation 78,000 tons, which would realize, at $45 per ton, $4,510,000. Besides the cost of freight, the expense of preparing the article for market would be $4 per ton for evaporating. The small lake already crystallized, and estimated only at a depth of six feet and an area of 155,000 feet, contains 30,660 tons, which at $45 per ton would realize $1,379,700.

Refraction of Sound.—Refraction of sound by the atmosphere was the subject of a paper read by Prof. Osborne Reynolds, at the last meeting of the British Association, in which were given the results of experiments made by the author. He had confirmed his hypothesis that when sound proceeds in a direction contrary to that of the wind it is not destroyed or stopped by the wind, but that it is lifted; and that at sufficiently high elevations it could be heard at as great distances as in other directions, or as when there is no wind. An upward diminution of temperature had been proved by Glaisher's balloon-ascents, and he showed, by experiments with the sounds of firing of rockets and guns, that the upward variation of temperature had a great effect on the distance at which sounds could be heard. By other observations, he found that when the sky was cloudy and there was no dew, the sound could invariably be heard much farther with than against the wind, but that, when the sky was clear and there was a heavy dew, the sound could be heard as far against a light wind as with it.

The Opium-Habit.—The British vice-consul at Kinkiang, China, in a report to his government, states certain facts coming under his own observation, which seem to show that the opium-habit may exist without detriment to health. During a tour on the Upper Yang-tse-kiang, he was thrown into the closest relations with junk-sailors and others, almost every adult of whom smoked opium. Their work was of the hardest, rising at 4 A. M., and working, with hardly any intermission, till dark, having constantly to strip and plunge into the stream in all seasons. The quantity of food eaten by them was prodigious, and from this and their work it may be inferred that their constitution was robust. The two most addicted to the habit were the pilot and the cook. On the incessant watchfulness and steady nerve of the former the safety of the junk and all on board frequently depended; the other worked hard from 3 A. M. to 10 P. M., and often longer. This cook had a conserve of opium and sugar, which he chewed during the day, as he was able to smoke only at night.

NOTES.

By a mistake of the printer, the heading to Dr. Jerome Kidder's advertisement in the last number of the MONTHLY was made to read, "Superior Electro-*Chemical* Apparatus." It should have read, "Superior Electro-Medical Apparatus," as it now stands.

LAST summer the French Assembly voted to M. Pasteur a life-pension of 12,000 francs, in consideration of his public services as a scientific investigator. Another pension of 6,000 francs was lately allowed him by a decree of the Marshal-President.

IN conjunction with the U. S. Fisheries Commission the Smithsonian Institution will exhibit at Philadelphia the resources of the United States derivable from the waters, including the objects themselves, the products derived from them, the apparatus by which the objects are captured or utilized, and finally the means by which they are multiplied and maintained in a healthy state. The last section is intended to illustrate the present state of pisciculture in this country.

AT the annual meeting of the American Microscopical Society of the City of New York, held on January 25th, Dr. John B. Rich was elected President, and Mr. C. F. Cox, 13 William Street, Secretary for the present year.

THE Loan Collection of Scientific Instruments, soon to be placed on exhibition in London, will undoubtedly be the most successful enterprise of the kind ever attempted. Nearly every civilized country will be represented. Not only modern instruments, but also those possessing a more strictly historical interest—such as apparatus once used by Galileo, Tycho Brahe, Lavoisier, Priestley, Boyle, Herschel, etc.—will have a place in this collection.

IN some parts of Russia the young shoots of the "cat-tail" (*Typha latifolia*) are used as asparagus; they are said to be delicious. The plant grows abundantly in the United States in swampy localities.

CAPTAIN ALLEN YOUNG will sail again next May, from England, to renew the search after the remains of Sir John Franklin's expedition. He will first visit the entrance of Smith Sound, with a view to receive intelligence from the Alert and Discovery.

THE death is announced of George Poulett Scrope, the geologist. He was born in 1797, and received his education at Harrow School and Cambridge University. In 1825 he published his first scientific work, "Considerations of Volcanoes." Two years later he published a treatise on "The Geology and Extinct Volcanoes of Central France," a work of signal merit. In 1833 he entered political life as a member of Parliament, and published a number of pamphlets on a variety of governmental topics. His later scientific writings consist of articles contributed to the *Journal of the Geological Society* and the *Geological Magazine.*

A SIGNAL for the use of the Coast Survey has been erected on the summit of Mount Shasta, California, at an elevation of 14,402 feet. It is described in the *Scientific American* as being a hollow cylinder of galvanized iron 12 feet high and 2½ feet in diameter, surrounded by a cone of nickel-plated copper, with concave sides, 3 feet high and 3 feet in diameter at the base. The nickel-plated cone is a brilliant reflector and will reflect the sunlight in such a manner that the reflection can be seen for a distance of 100 miles or over.

ONE of the grandest engineering projects of the time is the union of the Black and Caspian Seas. The plan is to join by a canal the tributaries of the Manytch and the Kouma, two considerable rivers which drain the northern slope of the Caucasus. If these two seas were united, the naval force of Russia would be practically doubled, for then her Caspian fleet could, in case of necessity, be added to that which holds the Black Sea.

AN old lioness in the Dublin Zoölogical Gardens was, during her last illness, much worried by rats, against which she could no longer defend herself. A terrier dog having been placed in the cage to protect the sufferer, the lioness at first received him with a surly growl; but, when she saw him kill the first rat, she began to appreciate her visitor. The lioness coaxed the terrier to her, folded her paws round him, and the dog slept each night on her breast enfolded with her paws, and protecting her rest from disturbance.

IT is stated in the *Tribune* that Prof. S. S. Haldeman recently found in an excavation in the vicinity of Chickies, Pa., a large number of Indian relics. The collection includes one hundred pieces of pottery, sixty stone arrow-heads, and one of copper; a tomahawk, eight stone chisels, several mallets and pipe-stems; also a few of those instruments commonly called "sinkers," but the proper use of which is unknown.

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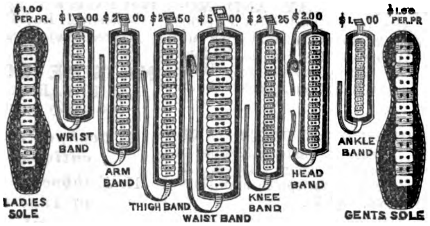

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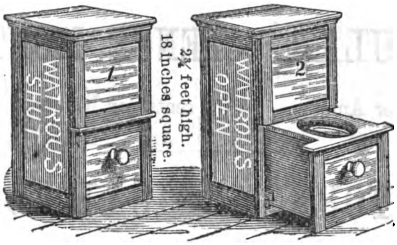

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junk and all on board frequently depended; the other worked hard from 3 A. M. to 10 P. M., and often longer. This cook had a conserve of opium and sugar, which he chewed during the day, as he was able to smoke only at night.

NOTES.

By a mistake of the printer, the heading to Dr. Jerome Kidder's advertisement in the last number of the Monthly was made to read, "Superior Electro-*Chemical* Apparatus." It should have read, "Superior Electro-Medical Apparatus," as it now stands.

Last summer the French Assembly voted to M. Pasteur a life-pension of 12,000 francs, in consideration of his public services as a scientific investigator. Another pension of 6,000 francs was lately allowed him by a decree of the Marshal-President.

In conjunction with the U. S. Fisheries Commission the Smithsonian Institution will exhibit at Philadelphia the resources of the United States derivable from the waters, including the objects themselves, the products derived from them, the apparatus by which the objects are captured or utilized, and finally the means by which they are multiplied and maintained in a healthy state. The last section is intended to illustrate the present state of pisciculture in this country.

At the annual meeting of the American Microscopical Society of the City of New York, held on January 25th, Dr. John B. Rich was elected President, and Mr. C. F. Cox, 13 William Street, Secretary for the present year.

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In some parts of Russia the young shoots of the "cat-tail" (*Typha latifolia*) are used as asparagus; they are said to be delicious. The plant grows abundantly in the United States in swampy localities.

Captain Allen Young will sail again next May, from England, to renew the search after the remains of Sir John Franklin's expedition. He will first visit the entrance of Smith Sound, with a view to receive intelligence from the Alert and Discovery.

The death is announced of George Poulett Scrope, the geologist. He was born in 1797, and received his education at Harrow School and Cambridge University. In 1825 he published his first scientific work, "Considerations of Volcanoes." Two years later he published a treatise on "The Geology and Extinct Volcanoes of Central France," a work of signal merit. In 1833 he entered political life as a member of Parliament, and published a number of pamphlets on a variety of governmental topics. His later scientific writings consist of articles contributed to the *Journal of the Geological Society* and the *Geological Magazine.*

A signal for the use of the Coast Survey has been erected on the summit of Mount Shasta, California, at an elevation of 14,402 feet. It is described in the *Scientific American* as being a hollow cylinder of galvanized iron 12 feet high and 2½ feet in diameter, surrounded by a cone of nickel-plated copper, with concave sides, 3 feet high and 3 feet in diameter at the base. The nickel-plated cone is a brilliant reflector and will reflect the sunlight in such a manner that the reflection can be seen for a distance of 100 miles or over.

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An old lioness in the Dublin Zoölogical Gardens was, during her last illness, much worried by rats, against which she could no longer defend herself. A terrier dog having been placed in the cage to protect the sufferer, the lioness at first received him with a surly growl; but, when she saw him kill the first rat, she began to appreciate her visitor. The lioness coaxed the terrier to her, folded her paws round him, and the dog slept each night on her breast enfolded with her paws, and protecting her rest from disturbance.

It is stated in the *Tribune* that Prof. S. S. Haldeman recently found in an excavation in the vicinity of Chickies, Pa., a large number of Indian relics. The collection includes one hundred pieces of pottery, sixty stone arrow-heads, and one of copper; a tomahawk, eight stone chisels, several mallets and pipe-stems; also a few of those instruments commonly called "sinkers," but the proper use of which is unknown.

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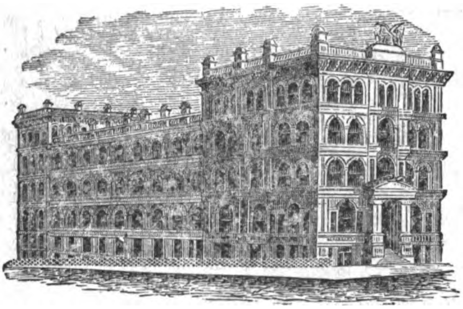

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